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The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

MAY, 1924

EUGENICS IN GERMANY
FRITZ LENTZ

MEIOSIS AND CROSSING OVER
R. RUGGLES GATES

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A. F. BLAKESLEE AND JOHN BELLING

INBREEDING IN THE PRATT FAMILY
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ALBINISM IN BARLEY
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Volume XV **Number 5**

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CONTENTS

CHROMOSOMAL MUTATIONS IN THE JIMSON WEED, DATURA STRAMONIUM.....ALBERT F. BLAKESLEE AND JOHN BELLING 195
HISTORY OF THE KRIEMHILD HERD (A REVIEW)..... 206
THE PRATT FAMILY.....FRANK BLAIR HANSON 207
SCIENTIFIC GENEALOGY (A REVIEW)..... 210
SOME VARIETIES OF WHITE RABBITS.....W. E. CASTLE 211
A SEEDLESS MUSKMELON.....L. J. COLE 219
ALBINISM IN BARLEY.....G. A. WIEBE 221
HAPPY WEDDED LIFE (A REVIEW)..... 222
EUGENICS IN GERMANY.....FRITZ LENZ 223
BRAHMA CATTLE RESISTANT TO TICK FEVER—NOT IMMUNE..... 231
A NEW APPROACH TO BIOLOGY (A REVIEW)..... 232
CROSS POLLINATION OF TOMATOES.....J. W. LESLEY 233
THE CHINESE BANANA IN THE PACIFIC ISLANDS..... 235
MEIOSIS AND CROSSING OVER.....R. RUGGLES GATES 237
THE INHERITANCE OF DEFECTS (A REVIEW)..... 240

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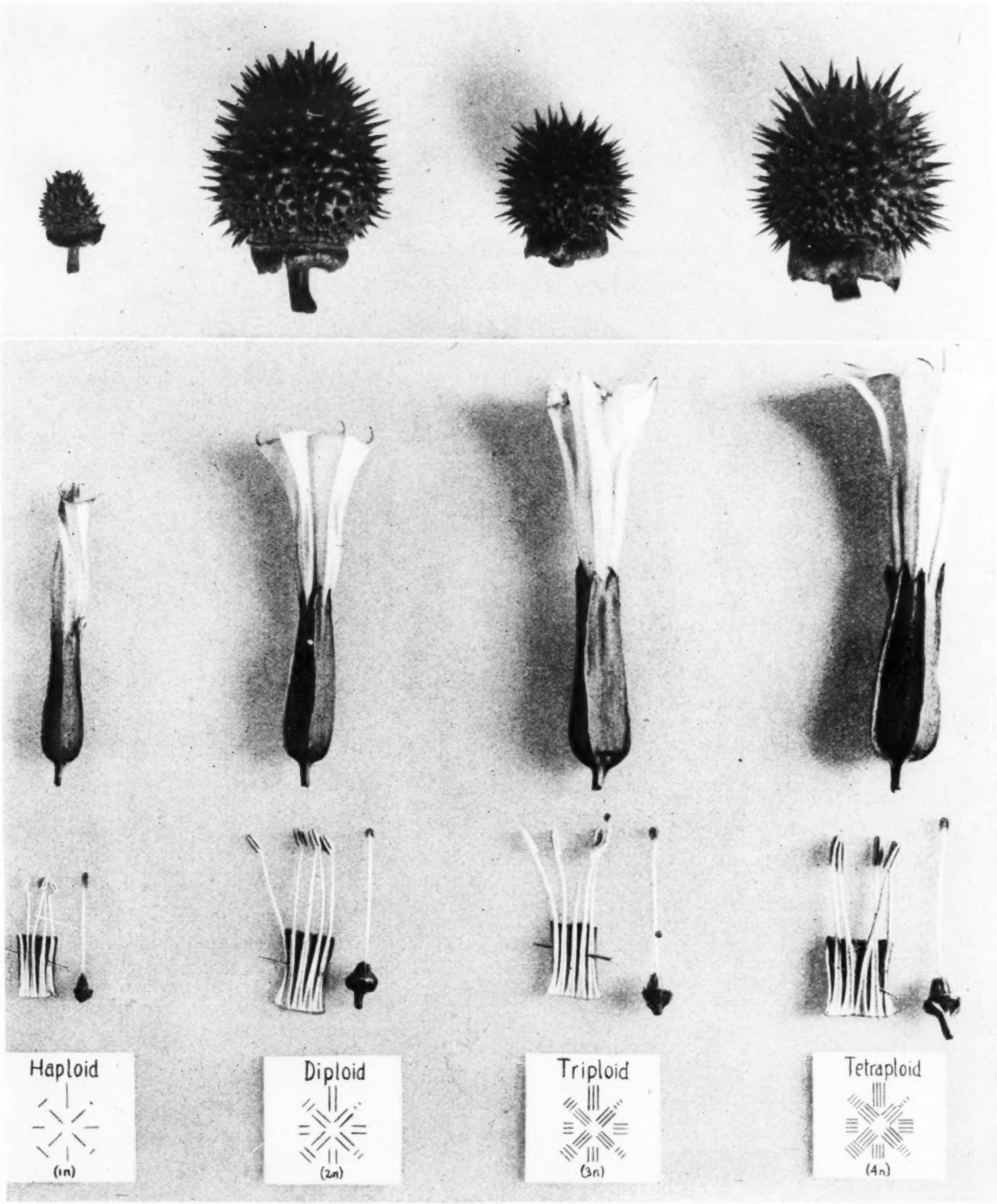


FLOWERS AND FRUIT CF BALANCED CHROMOSOMAL TYPES

Typical capsules, flowers, pistils, and stamens are shown of haploid (1n), diploid (2n), triploid (3n), and tetraploid (4n) Jimson Weeds. Diagrams to show the differences in chromosome number in these four types are at the bottom of the picture. An increase in size of flowers and floral parts is seen to accompany the increase in number of chromosomes. The capsules of the odd-balanced types (1n and 3n) are smaller, apparently because of the smaller number of seeds which they contain. For explanation of difference between balanced and unbalanced types, see Figure 2. (Frontispiece.)

CHROMOSOMAL MUTATIONS IN THE JIMSON WEED, DATURA STRAMONIUM

ALBERT F. BLAKESLEE AND JOHN BELLING

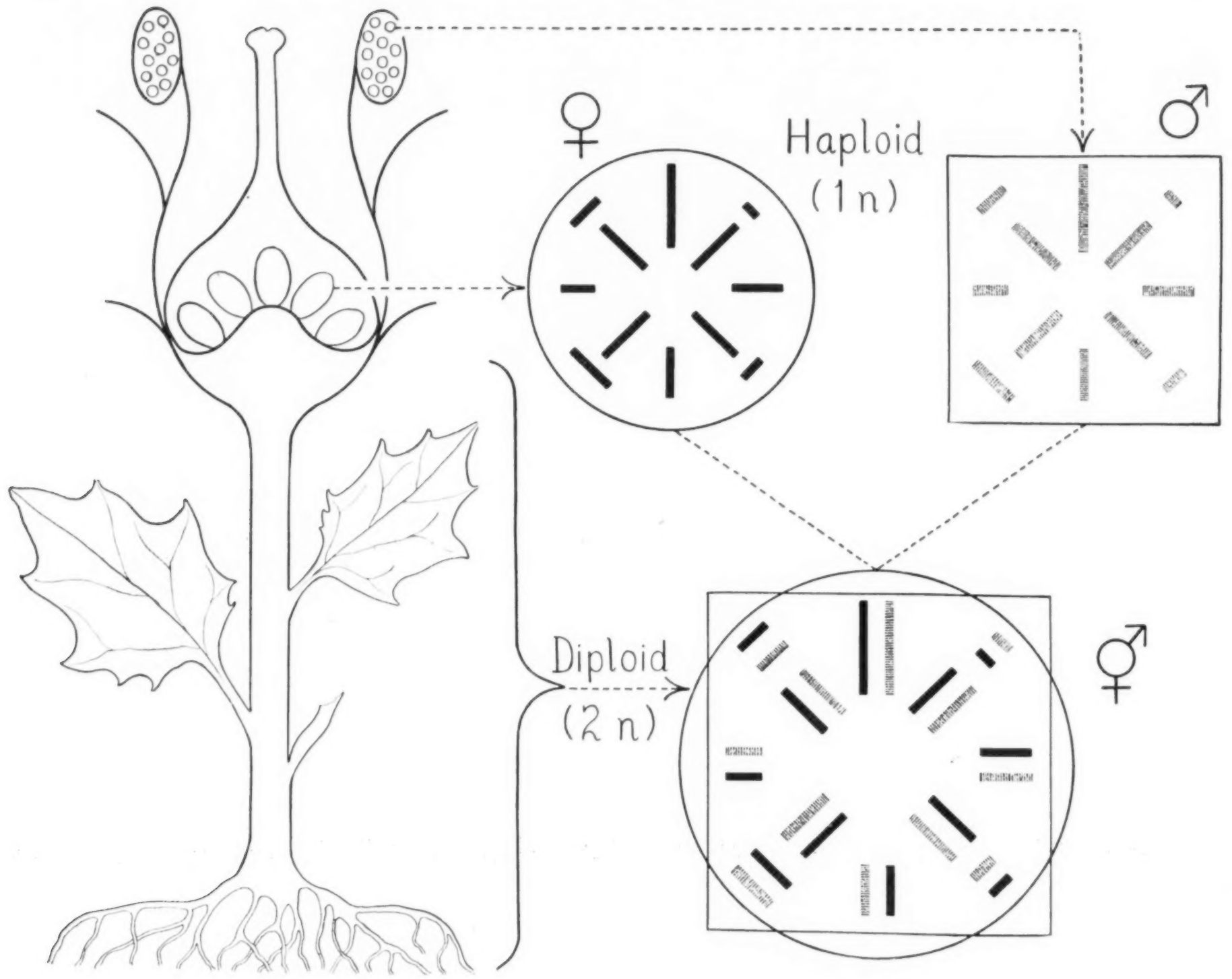
Station for Experimental Evolution, Cold Spring Harbor, N. Y.

IN THE *Journal of Heredity* for March, 1919, an article was published on mutations in the Jimson Weed (*Datura Stramonium*), in which a number of recurrent variant types are figured and briefly described. With one exception (the type called "New Species"), the new forms which occasionally appeared in our cultures could not be made to breed true. Only about a quarter of the offspring of such a common mutant as the Globe, for example, were like their parent, the remaining three-quarters being normal. These mutants were distinguished from the normal plants from which they arose, not merely by single visible differences, but by a complex of characters which are transmitted intact to their offspring. In this respect they resemble mutants in the classical genus Oenothera. At the time of the previous paper, the chromosomal constitution of the Datura mutants had not been determined. More recent investigations, however, have shown that the number and arrangement of chromosomes in the Jimson Weed furnish a clue to peculiarities in structure and breeding behavior found in this species.

The present paper is the first of a series of illustrated articles in this journal on the relation between variations in external appearance, breeding behavior and chromosomal arrangement in Datura. It aims to introduce the reader to the main chromosomal types which have appeared in our cultures during the last ten years. Many of the facts have been previously published in more technical journals, but much appears here for the first time, and all the illustrations are new.

Normal Arrangement of Chromosomes

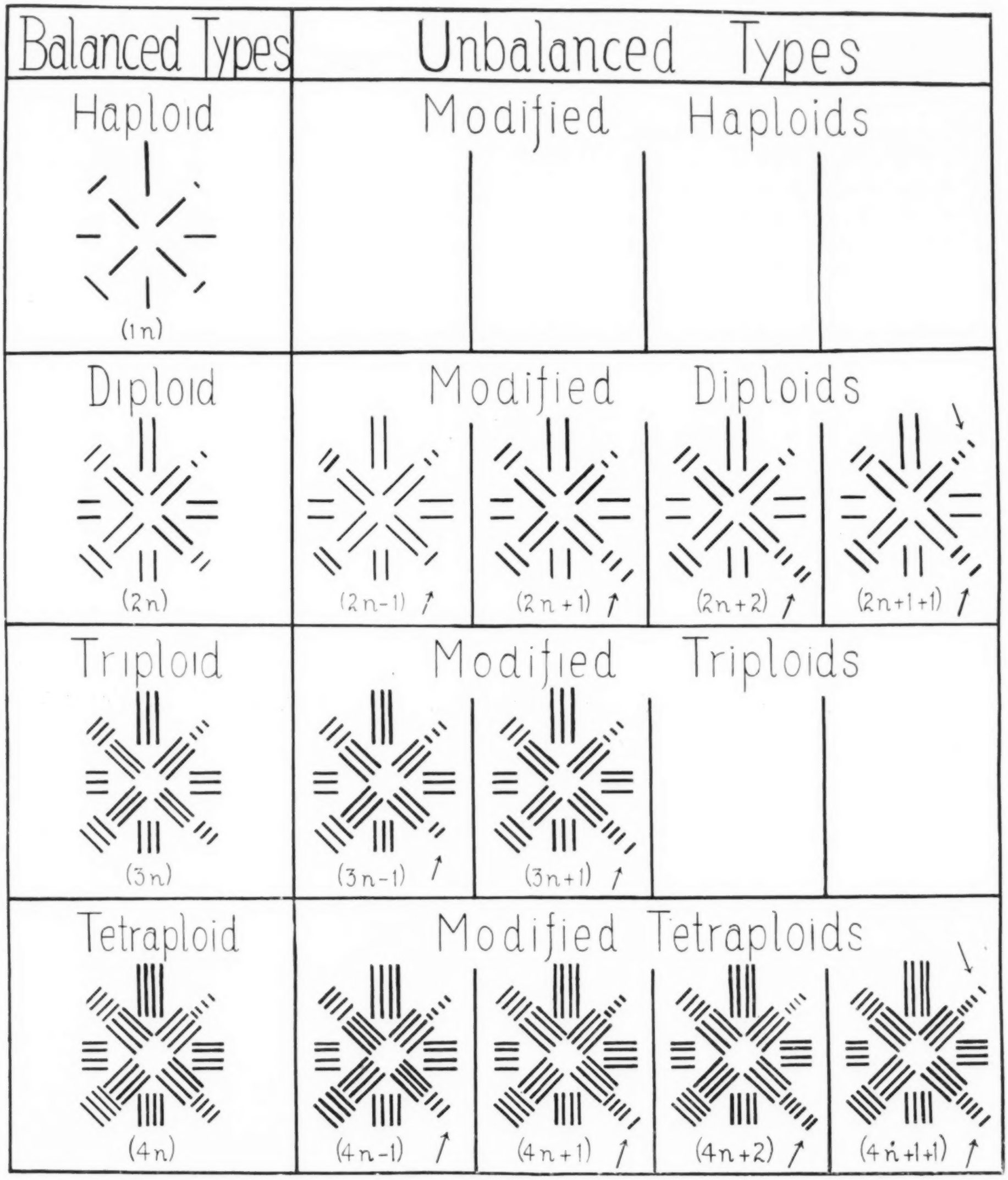
Before discussing the peculiarities brought about by abnormal arrangement and behavior of chromosomes, it will be well to consider for a moment the chromosomes in a normal Jimson Weed. Figure 1 is a diagram intended to represent a plant of the Jimson Weed with a single enlarged flower. It need hardly be pointed out to most readers that all parts of the plant—roots, stem, leaves and flowers—are made up of microscopic units, roughly analogous to the building bricks of an architectural structure, and that in each cell there is a definite number of still smaller rod-shaped bodies called chromosomes. The name chromosome means merely "colored body," and was given to these protoplasmic rods because they became strongly colored when acted upon by certain dyes. Their interest to the student of heredity, of course, lies in the fact that they are the bearers of hereditary factors which are transmitted from parent to offspring. Throughout the vegetative parts of the plant, there are two of each kind of chromosomes as shown diagrammatically at the right of the bracket. Since there are two chromosomes in each of the twelve sets, this part of the plant is called the 2n or diploid stage. At every division of a cell in the diploid stage, each chromosome divides longitudinally into two bodies like itself, until the divisions preceding the formation of the egg cells within the ovary and of the pollen grains within the stamens, when the chromosomes fail to undergo the usual process of division, and one entire chromosome from each pair migrates into each of



REPRODUCTIVE CYCLE IN THE JIMSON WEED

FIGURE 1. The entire plant is made up of microscopic cells, within each of which are minute rod-shaped bodies called chromosomes—the carriers of the hereditary factors. The diploid (2n) stage comprises the stem, roots, leaves, and conspicuous parts of the flower, in all of which the chromosomes are in pairs in each of the twelve sets, as shown at the right. When egg cells and pollen grains are formed, the number of chromosomes is reduced one-half; there being in the haploid or 1n stage, represented by the sex cells, only a single chromosome from each set (See Figure 7). When these male and female sex cells unite in fertilization the number of chromosomes is doubled, and the haploid stage begins again.

the two daughter cells, thus reducing the number of chromosomes by half. (Shown diagrammatically in Fig. 7.) In this reduced, haploid, or 1n stage there is only a single chromosome in each set, as shown in the diagram. According to the conventional use, a circle represents the female sex cell and a square the male sex cell. After pollination, when the pollen tubes have grown down to the ovary and have let out the male sex cells, fertilization takes place by the union of the latter with the egg cells, and the number of chromosomes is doubled as the plant passes back to the 2n or diploid stage. All the higher plants and animals show this distinction between a 2n stage, in which there are two chromosomes in each set; and a 1n stage, including the sex cells, in which there is only one chromosome in each set. The number of sets, however, varies widely among the different species, although constant for any given form. Thus in the fruit fly there are four chromosomal sets, in man twenty-four sets, in the nightshade thirty-six sets, and in the Jimson Weed twelve sets. In many species there is no visible difference between the individual chromosomes, although the breeding evidence may prove



CHROMOSOME TYPES IDENTIFIED IN THE JIMSON WEED

FIGURE 2. In the balanced types, the same number of chromosomes are found in each set. The odd-balanced types (1n, 3n) cannot breed true because similar sex cells cannot be formed (See Figure 1). The even-balanced diploids (normal plants) and tetraploids do breed true. Unbalanced types do not have the same number of chromosomes in each set. There may be one less, one more, or two more than the normal number in one set; or extra chromosomes in each of two different sets. The diagram shows roughly the relative sizes of the chromosomes, but the arrangement is purely diagrammatic.

that they carry different factors. In the Jimson Weed, however, size classes can be distinguished, as shown diagrammatically in the figures. It should be pointed out that, although the diagrams show roughly the relative sizes of the chromosomes, the arrangement is purely diagrammatic. The point to be emphasized is the grouping of the chromosomes into 12 separate sets although their association into such sets can be seen only in the nuclei immediately preceding reduction.

Abnormal Arrangement of Chromosomes

While no change in the number of twelve chromosomal sets is known to have taken place in the Jimson Weed, a considerable variation in the number of chromosomes within the sets may occur. The chief chromosomal types that have been identified are shown diagrammatically in Figure 2. Since these diagrams represent the condition in the adult plant, only the diploid (2n) condition is normal. The plants are classified into balanced and unbalanced types according to whether or not all the sets have the same number of chromosomes.

Balanced Chromosomal Types

Balanced types may be still further divided into even-balanced or stable, and odd-balanced or unstable types. The former have an even number of chromosomes in each set, form sex cells with half the number of chromosomes, and hence breed essentially true. The latter have an odd number in a set, and are therefore unable to form sex cells with an equal division of chromosomes, and hence cannot breed true.

Flowers, floral parts and capsules of balanced types are shown in the Frontispiece. An increase in size of cells and organs of the plant is the rule in going from 1n to 4n forms, as is seen in the flowers in the photograph. The 4n capsule is broader and more nearly spherical than the 2n capsule; and in respect to capsule shape, we seem to have a qualitative rather than a mere quantitative change of form. It will be noted that the odd-balanced 1n and 3n capsules are much reduced in size, probably because of the small number of seeds which they contain.

Tetraploids (4n) have occurred spontaneously a considerable number of times in our cultures in several different lines. The exact stage at which the doubling of chromosomes takes place has not yet been determined although evidence on this point is being accumulated. Tetraploidy is of considerable interest since it conceivably may have been a method in the evolution of species. Certainly if found growing wild, tetraploids would be classified by taxonomists as specifically distinct from the 2n race from which they arose. They seem to breed true, and are almost entirely sterile with the parental form. It is for this reason that in our previous paper in this journal the form was figured under the name "New Species." From over 200 attempted crosses with diploids, the tetraploid being used as the male parent, not a single offspring resulted. When a similar cross is attempted with the diploid as the male parent, at best only an occasional viable seed results. Only the facts that our tetraploids have not been found growing wild and that their origin under cultivation is known, have prevented their classification as a new species.

Triploids (3n) have never appeared spontaneously in our cultures. They have been obtained, however, in small numbers by crossing tetraploids (4n) by diploid (2n) male parents. Since the sex cells of tetraploids and diploids are respectively 2n and 1n, we should expect such a cross to produce 3n individuals in the offspring. This is the case, with the addition of some diploids produced by parthenogenesis.

Diploids (2n) are normal plants and need not be discussed further at this time.

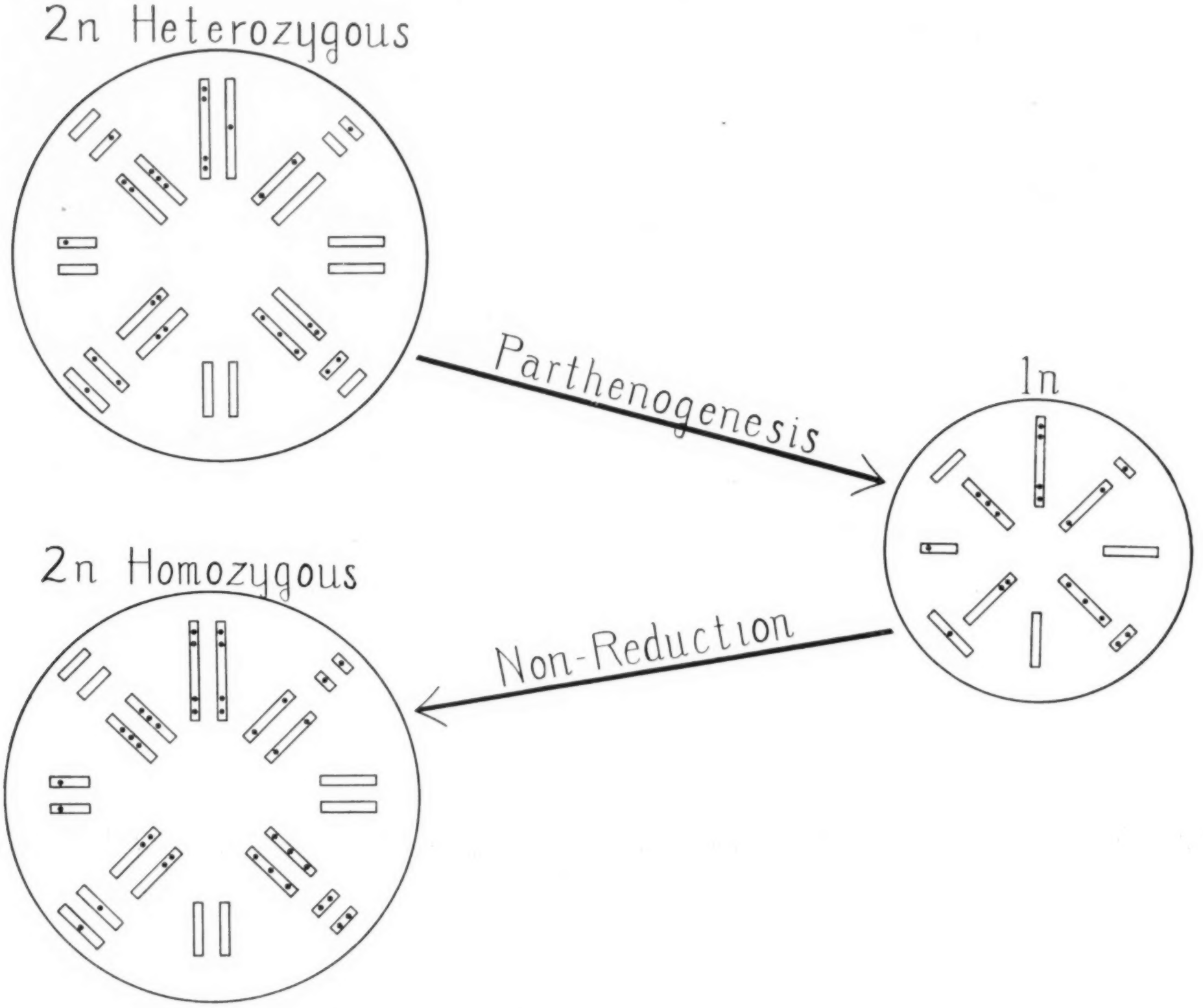
Haploids (1n) have the same chromosomal number as the sex cells. In growth they are not so inferior to normal plants as might be expected.

HAPLOID JIMSON WEED PLANT

FIGURE 3. Haploid (1n) plants have the same number and arrangement of chromosomes in their somatic cells as are found in the sex cells in normal plants. Such plants had never been found as the adult stage of any species of flowering plant until discovered in the Jimson Weed. Apparently haploids are produced by parthenogenesis—the development of an egg cell without fertilization.

Figure 3 shows a pot-grown plant. Haploids have never before been found among flowering plants, but it is possible they have been overlooked.[1] Since first reporting a haploid Datura in 1922, we have discovered twenty, all told, in our cultures. Evidence is good that they arise through parthenogenesis of the reduced egg, since haploids which have been produced after an interspecific cross resembled the female and not the male parent. Haploids cannot undergo a true reduction. They succeed only in forming abortive sex cells, pol-

[1]Since the manuscript of the present article was submitted, R. E. CLAUSEN and M. C. MANN, in *Proc. Nat. Acad. Sc.* 10:122-124, 1924, have reported the discovery of two haploid plants in tobacco.



PRODUCTION OF A PURE LINE FROM A HAPLOID PLANT

FIGURE 4. The discovery of haploid Jimson Weed plants opened up a new and simple way to establish pure lines from a highly heterozygous plant. The chromosomes of such a plant are represented schematically at the upper left of the figure, the dots in the chromosomes representing the hereditary genes or factors. Notice that these are unlike in the homologous pairs of chromosomes. By parthenogenesis (the development of an egg cell without fertilization), a haploid plant, represented at the right, is produced. Occasionally such a plant makes, by non-reduction, viable sex cells, which have chromosomes exactly like those of the parent plant. The chance union of two such cells, with exactly similar chromosomes, produces a homozygous diploid plant, in which the two chromosomes in each set are alike in all respects, as shown in the lower left. Such a plant is the starting point for a pure line.

len mother-cells producing daughter-cells with 6+6, 5+7, 4+8 chromosomes and the like, which go to form the imperfect pollen grains.

Pure Lines Produced from Haploids

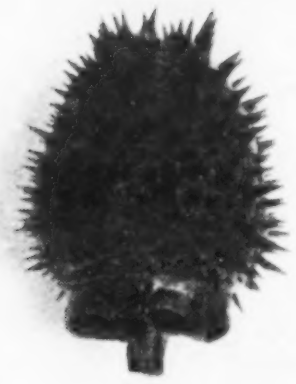
By non-reduction, normal sex cells with twelve chromosomes, are formed at rare intervals by haploids, and in consequence an occasional seed is produced by the self-pollination of this form. Such seeds are, of course, diploid (2n), and give rise to normal diploid plants, which, barring new mutations, must be absolutely homozygous. Why this is so, will be made clearer from the diagram in Figure 4 We may start with the 2n plant, the chromosomes of which are represented at the upper left-hand corner of the figure. This plant is assumed to be highly heterozygous with most of the sets having their two chromosomes unlike, as indicated by the dots representing hereditary factors, or genes. If the reduction division is followed by

parthenogenesis, a haploid (1n) plant with the arrangement of chromosomes shown at the right, would result. Both the male and female sex cells which a haploid plant occasionally forms by non-reduction must have identically the same chromosomes possessed by the parent haploid. Consequently, when 2n offspring arise from a haploid, provided new gene mutations do not occur during the process, they must be absolutely homozygous—more alike than two peas in a pod—as indicated by the chromosomes in the lower left-hand corner of the figure. Haploidy, therefore, affords a new and rapid method of converting a heterogeneous stock into a pure line. Heretofore we have depended upon inbreeding for many generations, but always with the fear that unconsciously we may be selecting heterozygous individuals if such plants happen to be the more vigorous. Our first 1n plant occurred in Line 1 and was labelled Haploid 1A. Diploids that have come from this haploid have been listed as belonging to Line 1A. We now have all the balanced types and the majority of the (2n + 1) types in Line 1A, and feel that we have as nearly comparable material as it is humanly possible to obtain. We now avoid inbreeding, instead of practicing it, in order to keep our line homogeneous, since the nearer we approach to our original haploid, which we have kept alive by grafting, the less likely is it that new gene mutations will have crept in.

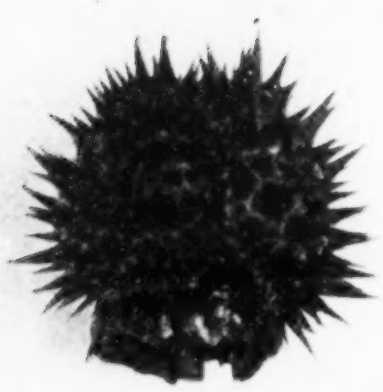
Unbalanced Chromosomal Types

We have discussed balanced chromosomal types in which there was the same number of chromosomes in each set. In many ways more interesting are the unbalanced types in which extra chromosomes occur in some, but not all, of the sets. Since there are twelve sets in the Jimson Weed in which an extra chromosome may be present, and since all the twelve sets contain different hereditary factors, we should expect twelve distinct mutant types represented by the formula (2n + 1). In Figure 5 are shown the capsules of what we believe to be these twelve Primary types, with the possible exception of Spinach, which may turn out to belong to the group of Secondary mutants, a discussion of which must be deferred to a later paper. It will be seen that the capsules of these twelve types are all different from each other, as well as from that of the normal 2n plant shown at the top of the picture. These differences enable us in a measure to determine what the factorial constitution of the various chromosomes really is. Thus we conclude that the extra chromosome which causes the plant affected to take on the peculiarities of the Globe mutant must contain factors for shortening and widening the capsule. For similar reasons the Cocklebur chromosome must contain factors that make the capsule narrow; the Echinus chromosome, factors for long spines; the Glossy chromosome, factors for a shiny surface; the Microcarpic chromosome, factors for a downy surface on the capsule; and so on for the others of the twelve.

The unbalance which extra chromosomes exert over the normal balanced condition may best be shown by capsules of the Globe mutants. Thus as shown in Figure 6, we have two diploid Globes, or, more properly speaking, two diploids modified by extra chromosomes in the Globe set. The (2n + 1) Globe has one extra chromosome in the Globe set giving an unbalance of one over the normal complement of twenty-four. The (2n + 2) Globe with two extra chromosomes in the same set has a greater unbalance (2 over 24) and in consequence all Globe characters, such as depression of the capsule, are heightened in expression. In similar manner starting with the capsule of a tetraploid at the right, it will be seen that the tetraploid Globes have their capsules relatively more depressed and their spines relatively stouter as we pass from (4n + 1) to (4n + 2) and (4n + 3) Globes. A (4n + 4) Globe has not yet appeared in our cultures, but we might expect it, since the un-



Normal

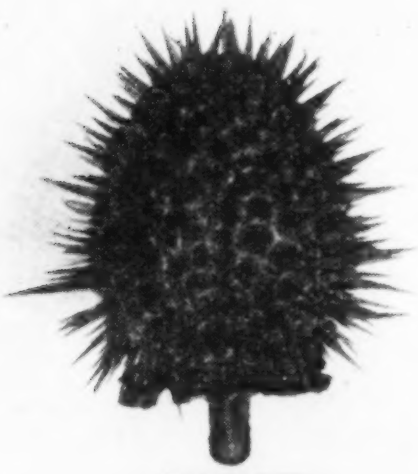


Globe

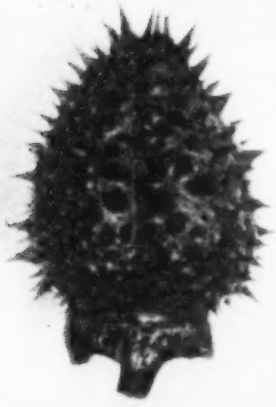
Poinsettia

Cocklebur

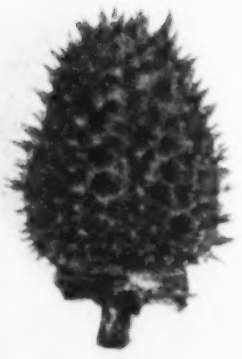
Ilex



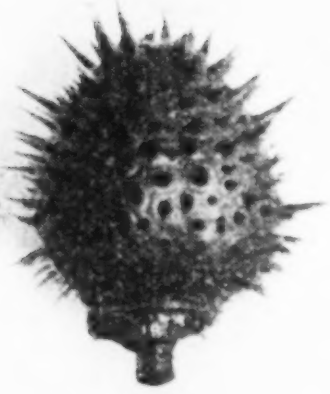
Echinus



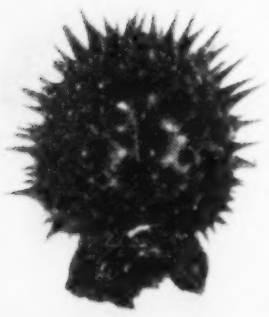
Rolled



Reduced



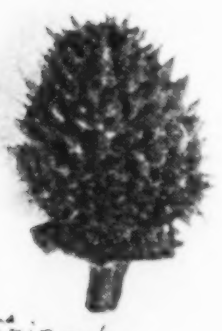
Buckling



Glossy

Microcarpic

Elongate



Spinach

CAPSULES OF UNBALANCED JIMSON WEED MUTANTS

FIGURE 5. At the top is shown a capsule of a normal (diploid) plant. Below are the capsules of twelve different mutant types, which may be represented by the general formula (2n+1) (See Figure 2). The peculiarities of each are caused by the presence of an extra chromosome in one of the twelve sets found in the Jimson Weed. Each of the twelve mutants owes its characteristics to the fact that this extra chromosome is in a different set in each case. Somewhat less than half the offspring of these unbalanced mutants are like the parent plant.

balance which its extra chromosomes exert would be four over forty-eight which is the same unbalance found in the (2n + 2) Globe (2 over 24). Similarly we might expect a haploid (1n + 1) Globe with an unbalance of one over twelve, but this unbalance, found as yet only in the rare (2n + 2) Globes, may be the limit of unbalance which a plant can endure, and may be possible only in the diploid series. Since the photograph was taken we have secured a (3n + 1) Globe by crossing a (4n + 1) Globe with a 2n pollen parent.

Double mutants represented by the formula (2n + 1 + 1) occasionally have appeared, in which two different sets have each an extra chromosome, and such plants in consequence show characteristics of two mutants. Thus a Globe-Reduced plant has an extra Globe chromosome and also an extra Reduced chromosome, and in appearance resembles both a Globe and a Reduced. In only a single case have we found a triple mutant with an extra chromosome in each of three sets.

The loss of a chromosome from one of the sets forming (2n—1), (3n—1), and (4n—1) types seems to be not so common as the addition of an extra chromosome, but such deficiency mutants have been obtained.

Among tetraploids, the addition or loss of a single chromosome does not cause so great an unbalance as among diploids. In consequence we have more complicated types capable of surviving among the former. Two types, (4n+1—1) and (4n+1+1—1—1), have been found, which, although having a total of forty-eight chromosomes characteristic of tetraploids, were shown by the numbers of the members in the sets, as well as by the external appearance of the plants, to be modified tetraploids with an addition in one set numerically compensated by a deficiency in another set. Such types show that a mere count of chromosome number is insufficient to prove a plant a true tetraploid.

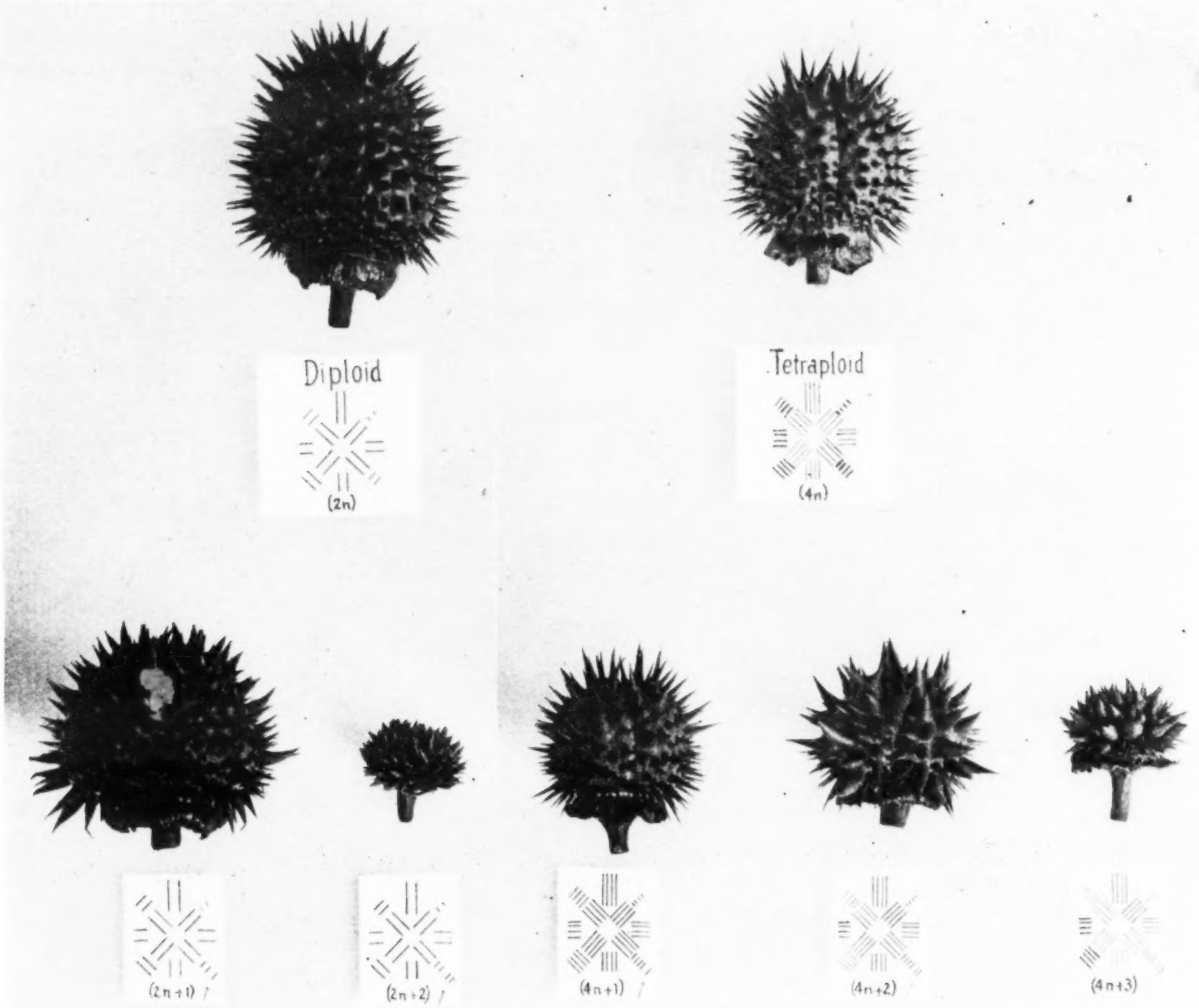
A summary of chromosomal types is presented in the accompanying table. The second column gives the number of forms which have been identified and the third column the number of forms possible in the given type, provided all are viable. If secondary mutants were included, the number of different forms theoretically possible would be greatly increased. The table is sufficient to show the wide range of variation possible in the Jimson Weed by changes in the number and arrangement of its chromosomes.

Origin of Abnormal Types

It will not be possible to discuss in detail the ways in which the mutant types may have arisen. Of the balanced types the method of origin of tetraploids is as yet uncertain; triploids, in our experience, have come only from the cross of 4n×2n; while haploids seem to have arisen by true parthenogenesis. The presence of a single extra chromosome in (2n+1) forms probably arises through non-disjunction, or the failure of one of the chromosomes to separate from its mate at division of the cell. At reduction division in such mutants, the extra chromosome is handed on to half the sex cells, which are less vigorous in consequence, the pollen grains with the extra chromosomes seldom functioning for this reason. As a consequence, considerably less than half (generally not over a quarter) of the offspring of a given mutant are like their parent. (See Figure 7.)

Disomic, Trisomic and Tetrasomic Ratios

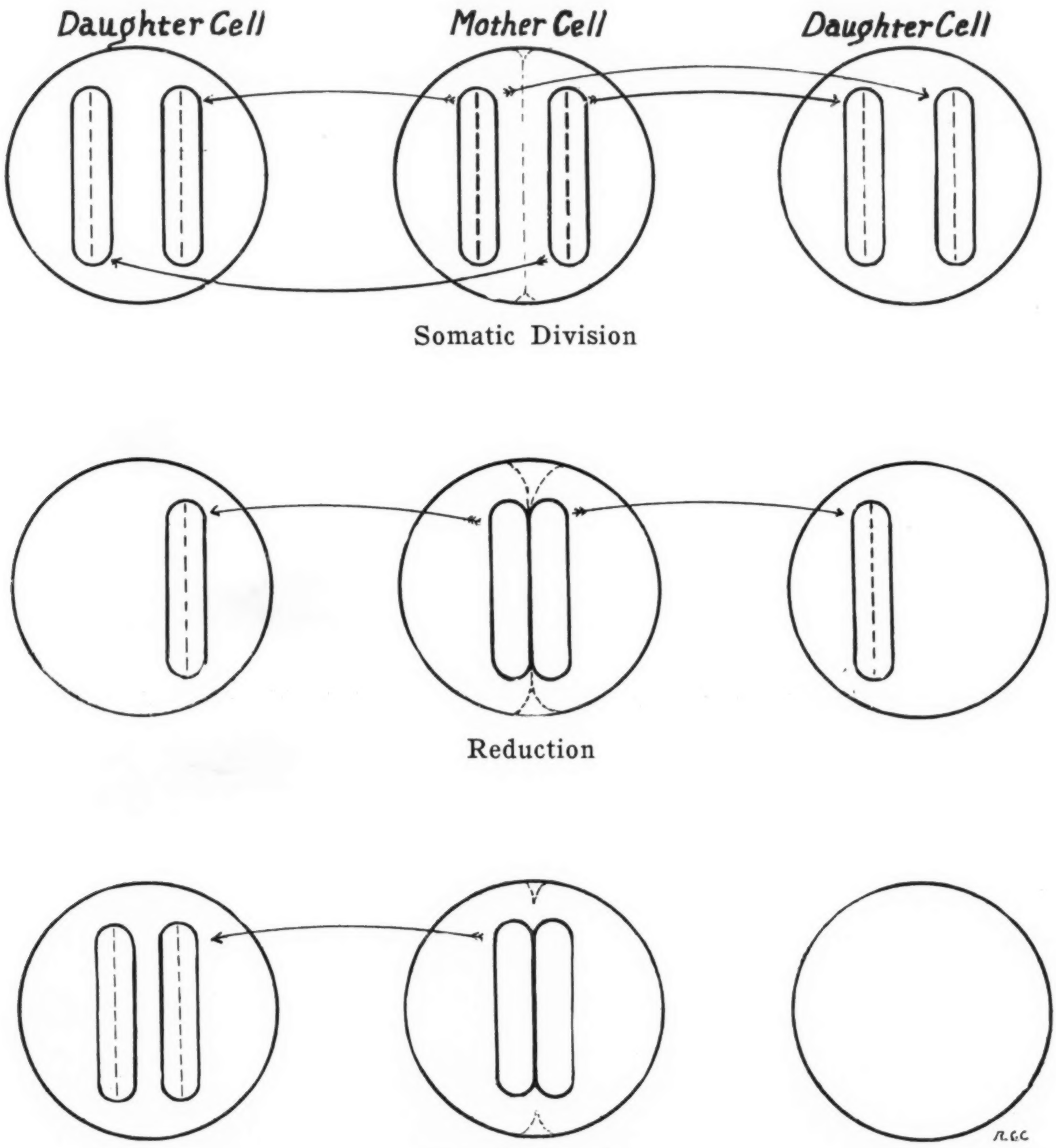
In diploids we have only one kind of heterozygous plants, which can be represented as Aa. These when selfed give the familiar disomic ratio 3A:1a. In (2n+1) forms, if the gene in question is in the set (or trisome) with the extra chromosome, there are two heterozygous types, A_2a and Aa_2. The first when selfed gives the trisomic ratios, 8A:1a among the normal, and 9A:0a among the mutant offspring; while the latter gives 5A:4a among the



CAPSULES OF FIVE GLOBE MUTANTS

FIGURE 6. Normal diploid and tetraploid capsules are shown above. Below, on the left, are two diploid Globes, with respectively one and two extra chromosomes in the Globe set. On the right are three tetraploid Globes, with respectively one, two, and three extra chromosomes in the Globe set. An increase in Globe peculiarities—depression of capsule, and relative stoutness of spines—is seen as the number of extra chromosomes in the Globe set increases.

normals, and 7A :2a among the mutants. Among tetraploids there are three heterozygous types which give tetrasomic ratios. A_3a gaves all A when selfed, A_2a_2 gives 35A :1a, and Aa_3 gives 3A :1a. In addition, a (4n+1) mutant will give pentasomic ratios for factors carried in the set with the extra chromosome. These ratios, together with those obtained from back-crosses and from crossing the different heterozygous types together, give a series which at first sight might appear to be in serious conflict with Mendel's law of inheritance. The law of Mendel, however, as familiarly known is merely the expression of chromosome behavior in normal diploids. That abnormal ratios occur from plants with abnormal arrangement of chromosomes is a necessary consequence, and strengthens our belief in the chromosomes as the carriers of the hereditary factors. That abnormal configurations of chromosomes in the Jimson Weed should induce definite abnormalities in appearance and breeding behavior is but an added proof of the specificity of the chromosomes — the abnormalities are exceptions which really prove the rule of inheritance known as Mendelian.



CHROMOSOME BEHAVIOR IN CELL DIVISION

FIGURE 7. In this chart is shown the behavior of a single pair of chromosomes in ordinary cell division, in reduction, or the formation of sex cells, and in non-disjunction—an abnormal mode of division that probably causes the production of unbalanced types (Figure 2). In somatic division each chromosome splits longitudinally and one-half goes to each of the daughter cells. In reduction the individual chromosomes do not split, but one entire chromosome from each pair goes to each of the daughter cells, reducing the number of chromosomes by half. In non-disjunction, both chromosomes of a pair go to one daughter cell, and none to the other.

TABLE I—*Chromosomal Types in Jimson Weed, Showing Number of Forms Mathematically Possible, and Number Actually Identified*

Chromosomal Types	*Number of Forms Identified*	*Number of Forms Possible*	*Chromosomal Types*	*Number of Forms Identified*	*Number of Forms Possible*
1n, 2n, 3n, 4n	4	4	4n+1	8	12
2n+1	12	12	4n+2	1	12
2n+2	1	12	4n—1	5	12
2n—1	1	12	4n+1+1	1	66
2n+1+1	10	66	4n+1—1	1	132
2n+1+1+1	1	220	4n—1—1	1	66
3n+1	1	12	4n+1+1—1—1	1	2970
3n—1	1	12			

History of the Kriemhild Herd

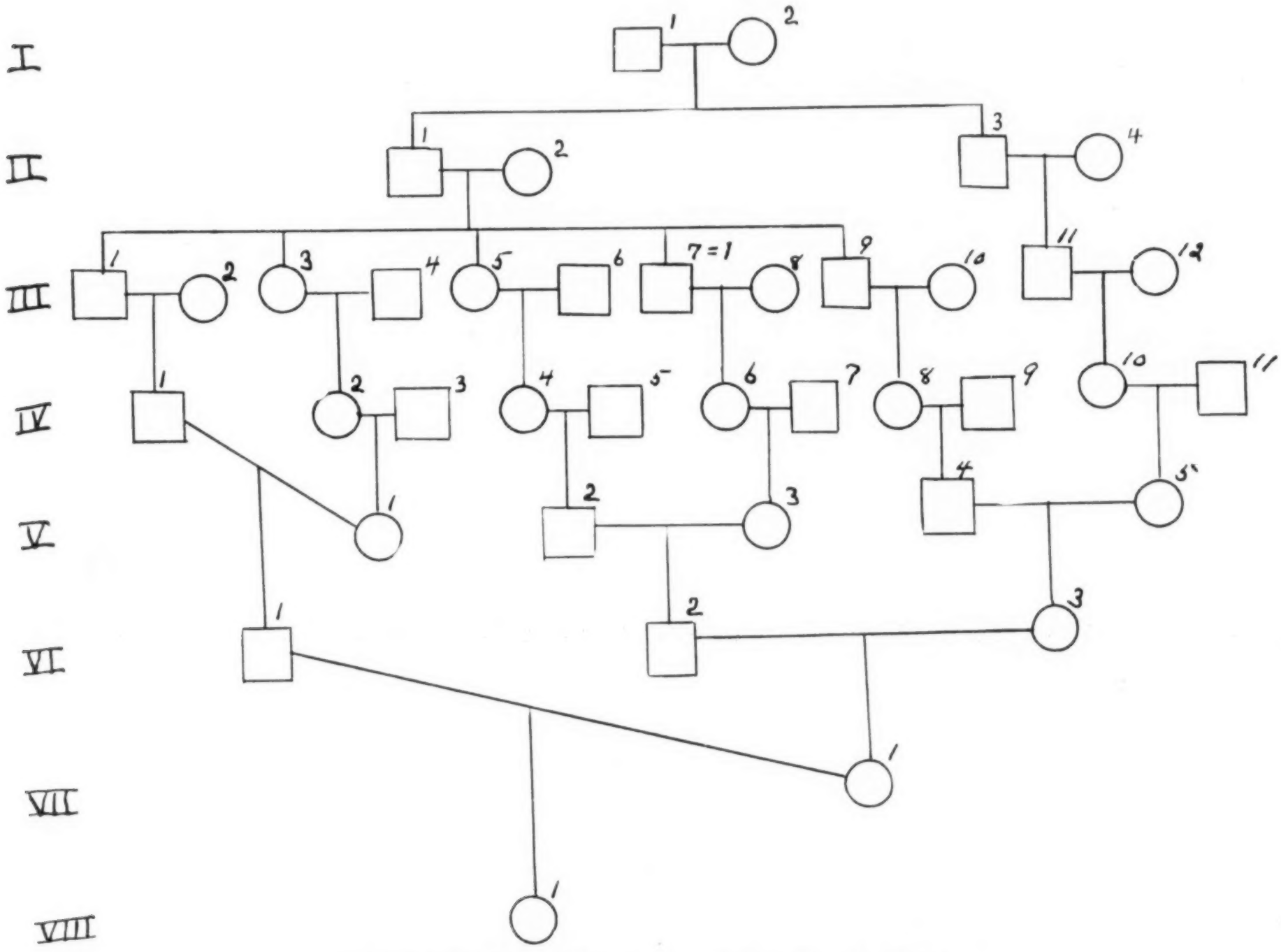
KRIEMHILD HERD, A Chapter in Holstein History, by FRANK NORTON DECKER. Published by the author, Syracuse, New York, 1923.

This booklet gives an account of the history of the oldest herd of American pure-bred Holstein-Friesian cattle still in existence and of its breeder, Hon. Gerrit Smith Miller. It is a surprising fact that the man who made next to the earliest importation from Holland which has contributed to the breed and who bred entry No. 1 in the old Holstein Herd Book, should still be actively engaged in breeding the same herd. More than a million Holstein-Friesians have now been registered. The blood of the animals imported and bred by Mr. Miller is now well distributed through the breed, including the best producing lines, to whose excellence they have undoubtedly been an important factor. The first annual record of production in a Holstein cow in America was made in this herd. All in all, few men have made a more notable contribution to American agriculture than Gerrit S. Miller and this brief account of his activities in developing the Kriemhild herd should be welcomed by students of cattle breeding. The treatment of the historical phase of the subject, it may be said, is much more satisfactory than the attempt to apply genetic principles to the data. The book is copiously illustrated with lithographs and photographs going back to the foundation animals of the herd. S. W.

THE PRATT FAMILY

A Record of Human Inbreeding for Eight Generations

FRANK BLAIR HANSON
Washington University, Saint Louis, Missouri



INBREEDING IN THE PRATT FAMILY

FIGURE 8. The relationship of some of the members of this family is rather complicated. For instance, Fern, the propositus, (VIII-1) is a third cousin once removed of her own mother, and a second cousin once removed of her own father. The family is evidently of very sound stock, for inbreeding has brought no hidden defects to light, and it is now generally recognized that inbreeding does not produce defects, but only uncovers recessive ones that would ordinarily remain hidden.

IN AN Extension Class on Evolution and Heredity taught by the author for a number of years, the family histories of the students have constituted the laboratory materials of the course.

Many interesting facts and family histories have come to light in this manner, most of which are now on file in the Eugenics Record Office, Cold Spring Harbor, Long Island.

The data in this article, which deals with a family history in which there has been a large amount of inbreeding, comes from an unusually able and thoughtful student of the above-mentioned class. This student is a member of the family described.

The family is one of the older and better known families of St. Louis. If mentioned by name it would be recognized by many as that of one of the

prominent pioneer families of this section of the country. The few given names used are the real names of the persons concerned, but the surname of Pratt is adopted as being as far removed from the actual family name as any other.

The propositus or central figure in the pedigree is Fern Pratt (VIII-1), who was born March 12, 1912. She is at present a pupil in the St. Louis public schools and is described as a perfectly normal, healthy child.

Fern Pratt (VIII-1) is descended from a certain John Pratt (I-1) six times in direct lines. On her father's side, John Pratt (I-1) is her great, great, great grandfather through one line, and also her great, great, great great grandfather through another line. While on her mother's side, this same individual, John Pratt, is her great, great, great, great, great grandfather four times through four direct lines. (See Figure 8.)

In the second generation Fern is descended from two brothers (II-1, 3), the sons of John Pratt. In the third generation she is descended from two brothers, Thomas (III-1, 7) and John (III-9), their two sisters, Mary (III-3) and Margaret (III-5), and their first cousin, James (III-11). Thomas (III-1, 7) was twice married and appears in the third generation as individual 1 and 7. It will be noted that Fern is also descended from both of the wives of Thomas.

In the fourth generation Fern is a direct descendant from five first cousins (IV-1, 2, 4, 6, 8), one half-brother (IV-1), a half-sister (IV-6), and one second cousin (IV-10).

In the fifth generation her ancestors are five second cousins (V-1, 2, 3, 4, 5), and a first cousin once removed. In the sixth generation three third cousins appear (VI-1, 2, 3); while in the seventh generation we have the union of two lines of ancestry that diverged from each other in the third generation.

Looking back over the pedigree we find some very interesting and complex relationships among the descendants of the original John Pratt. For instance, Thomas (III-1, 7) is Fern's great grandfather through his first wife (III-2), and also her great, great, great grandfather through his second wife (III-8).

Similarly, Washington (IV-1) married the daughter of his own first cousin, making him a first cousin, once removed, to his own wife, and making his son Ralph (VI-1) a second cousin to his own mother.

On her father's side, Fern's grandfather (IV-1) and great grandmother (IV-2) are first cousins to each other. In the fifth generation (on the mother's side) three of the great grandparents (V-2, 3, 4) are second cousins to each other, and are third cousins to Julia (V-5), which latter is the wife of her third cousin (V-4).

The grandfather (IV-1) and the great grandmother (IV-2), on the father's side, who are first cousins to each other, are both first cousins to three of the great, great grandmothers (IV-4, 6, 8) on the mother's side, and second cousins to the fourth great, great grandmother (IV-10).

We further find that Fern's grandmother (V-1) on her father's side is a second cousin to three of her great grandparents on her mother's side (V-2, 3, 4), and also a third cousin to the fourth great grandparent (V-5). Fern's father (VI-1) is a second cousin (once removed) to her grandparents on her mother's side, which makes Fern a third cousin to her own grandparents on her mother's side, a third cousin (once removed) to her own mother, and a second cousin (once removed) to her own father.

Her Missing Ancestors

Inbreeding may be defined as a process of mating whereby an individual has fewer than the maximum number of ancestors in any generation or generations. "It means," says Raymond Pearl, "that the number of potentially

different germ-to-germ lines or 'blood-lines' concentrated in a given individual is fewer if the individual is inbred than if he is not."

When we consider the numerical ancestry of Fern Pratt, we find that in the period covered by the pedigree she is entitled to a maximum number of 254 ancestors. Actually she is descended from only 142 different people. In the first generation of the chart she could have as many as 128 ancestors—she is actually fifty-eight ancestors short in this one generation, that is, she has a total of seventy instead of 128. Since these figures are computed upon the basis of no inbreeding at all in the family lines into which the Pratt family married, and since it is highly improbable that such was the case, the actual number of ancestors possessed by Fern during the period covered by the pedigree is undoubtedly far under the number mentioned above.

One of the striking facts long known to biologists is that "lines of descent terminating in any one individual, though they radiate back in widening angles for a time, would seem to gather again in a comparatively few individuals if the pedigree could be traced in its entirety." (East-Jones). This fact has been overlooked sometimes, and beginning with two parents, four grandparents, eight great grandparents, etc., the conclusion has been drawn that in the tenth generation there were 1,024 different ancestors. A recent article by a leading geneologist has this entirely erroneous statement: "Remember that each parent has four grandparents. With three generations to the century, in a thousand years you have hundreds of thousands of ancestors."

Professor W. K. Brooks studied the ancestry of the people of a small island off our eastern coast. Taking three individuals who were not near relatives at all, he found that of the maximum number of 1,146 ancestors they might theoretically have had in seven and one-half generations, the names of 452 of them, or nearly half, were recorded. But these 452 named ancestors were not 452 distinct persons, but only 149.

> Few of us know even the names of all the living descendants of each of our sixty-four ancestors of the sixth generation; and, so far as our own choice is concerned, marriage with one of them may be an accident; for the probability of such a marriage depends upon things which are in great part independent of us, upon the size of the circle of acquaintances, and the distance of the places to which ancestors wandered. For if each pair of ancestors had only four children, more than twelve thousand of their descendants may now be living (4048+8096).
>
> If a city like Baltimore, where the strangers to each one of us outnumber our acquaintances a thousandfold, could be quarantined against people from outside for a thousand years, each successive generation would be much like the present, so far as known relationships are concerned, although, at the end of this period, the inhabitants would not be descended from the Baltimoreans of our day, but only from a very few of them. Most of our lines would be extinct; and the few that survived would include most of the Baltimoreans of the year 2898.—K. W. Brooks. *Effects of Inbreeding.*

If we grant that there is considerable inbreeding in any old, well established community, and that not knowing even the names of the descendants of each of our sixty-four ancestors of the sixth generation back, we may well marry a relative without suspecting the relationship, our next question is as to the results of such chance matings with unknown relatives. In other words, what are the effects of inbreeding in the human family?

This was evidently among the earliest questions discussed by man. Breeders have pointed out its advantages and disadvantages. Most of the earliest literature is largely speculative, but it should be noted that Darwin carried on a series of inbreeding experiments on plants over a period of eleven years.

Recently a number of experiments have been reported by various investigators on the effects of inbreeding. East and Jones in their book, *Inbreeding and Outbreeding*, have summar-

ized all this work and from it have drawn certain conclusions. For the details of the experiments themselves the reader is referred to the book by East and Jones.

Suffice it to say here that the older view that inbreeding is *per se* injurious is being rapidly replaced by another, namely, that "inbreeding has but one demonstrable effect on organisms subjected to its action—the isolation of homozygous types." In the light of the newer experimental work of King, Wright, Castle, East and Jones, and others, it seems to be clearly established that inbreeding is not injurious merely by reason of the consanguinity involved.

The only injury proceeding from inbreeding comes from the inheritance received. The constitution of the individuals resulting from a process of inbreeding depends upon the chance allotment of characters preexisting in the stock before inbreeding was commenced. If undesirable characters are shown after inbreeding, it is only because they already existed in the stock and were able to persist for generations under the protection of more favorable characters which dominated them and kept them from sight. The powerful hand of natural selection was thus stayed until inbreeding tore aside the mask and the unfavorable characters were shown up in all their weakness, to stand or fall on their own merits.

If the evil is brought to light, inbreeding is no more to be blamed than the detective who unearths a crime. Instead of being condemned it should be commended. After continued inbreeding a cross-bred stock has been purified and rid of abnormalities, monstrosities, and serious weaknesses of all kinds. Only those characters can remain which either are favorable or at least are not definitely harmful to the organism. Those characters which have survived this "day of judgment" can now be estimated according to their true worth. As we shall see later, vigor can be immediately regained by crossing. Not only is the full vigor of the original stock restored, but it may even be increased, due to the elimination of many unfavorable characters. If this increased vigor can be utilized in the first generation, or if it can be fixed so that it is not lost in succeeding generations, then inbreeding is not only not injurious but is highly beneficial. As an actual means of plant and animal improvement, therefore, it should be given its rightful valuation.—East and Jones.

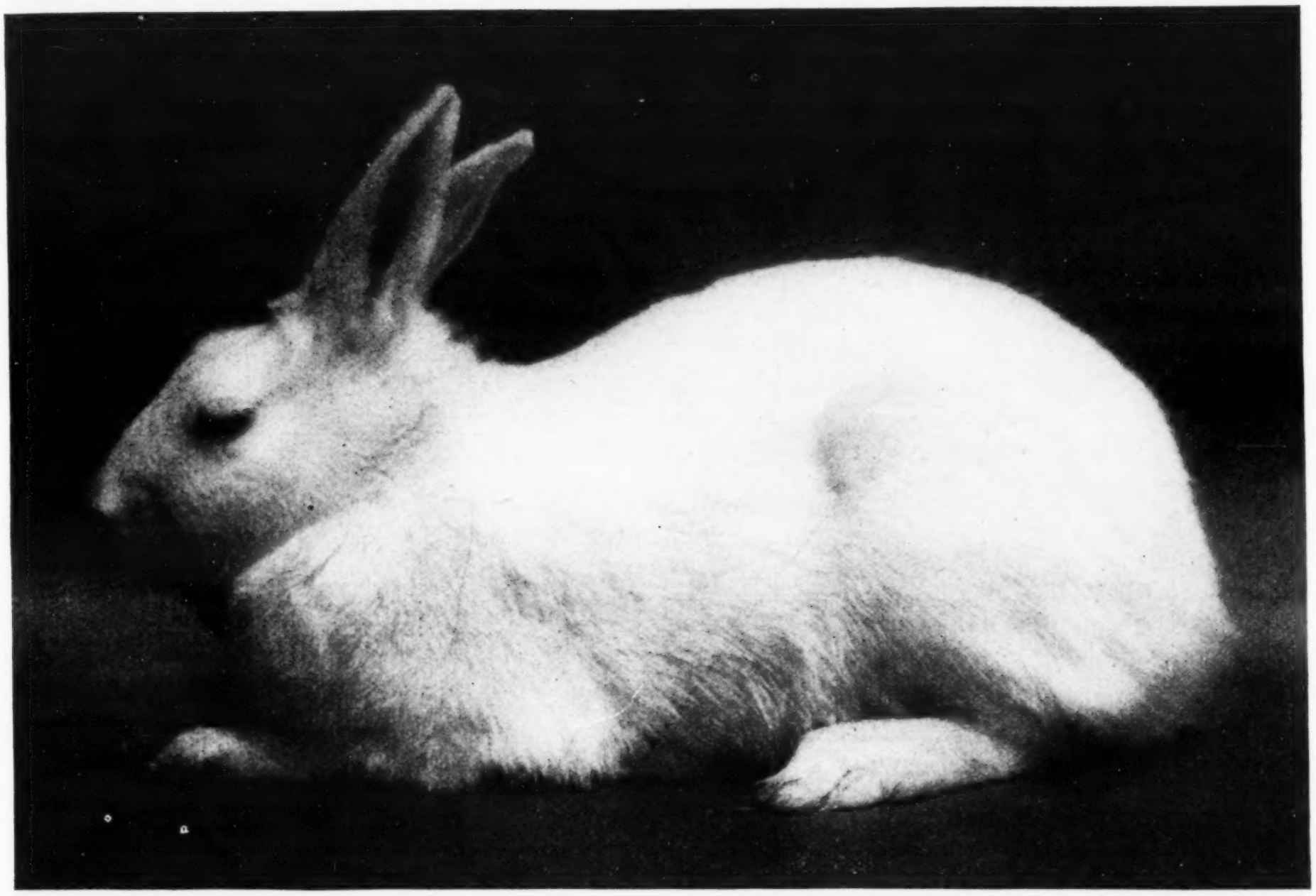
Scientific Genealogy

Einfuehrung in die Naturwissenschaftliche Familienkunde (Familienanthropologie), u. Dr. Walter Scheidt, Assistant in the Anthropological Institute of Munich University. Pp. 215, with 11 illus. Price $1.20. Munich, J. F. Lehmanns Verlag, 1923.

No one interested in genealogy from a biological point of view can afford to overlook this book, which covers the ground more completely than anything published in the English language. After a general consideration of heredity and of the family from an anthropological standpoint. Dr. Scheidt gives a summary of the known data regarding the inheritance of normal (nonpathological) characters. This will be useful to the specialist but perhaps confusing to the layman, for there is little definite knowledge about the inheritance of such characteristics in man, and the published opinions differ widely. Detailed directions for making a family study follow; a concluding chapter considers the value of such studies in general. A full bibliography is added, while a pocket in the back cover contains specimens of the blank forms used at the Munich Clinic for biological family studies. Even though the critical reader may find many things with which he will not agree, he will recognize the value of Dr. Schiedt's work as the first step toward the organization of a field of research that is destined to play an important role in the future but has hitherto been almost ignored. P. P.

SOME VARIETIES OF WHITE RABBITS

W. E. Castle
Harvard University.

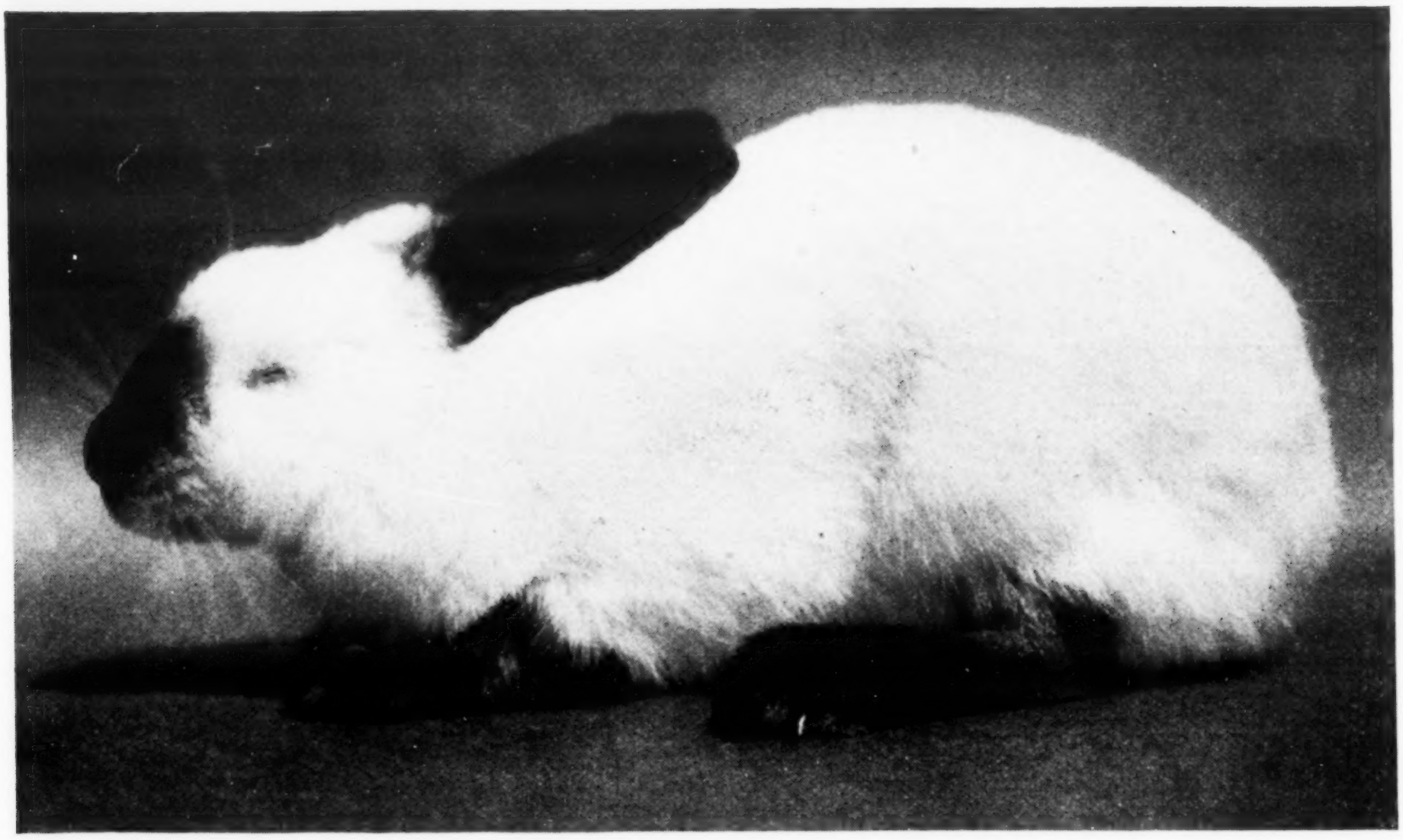


TRUE ALBINO RABBIT

Figure 9. The best known form of albino rabbit, snow white with pink eyes—a simple recessive character in crosses.

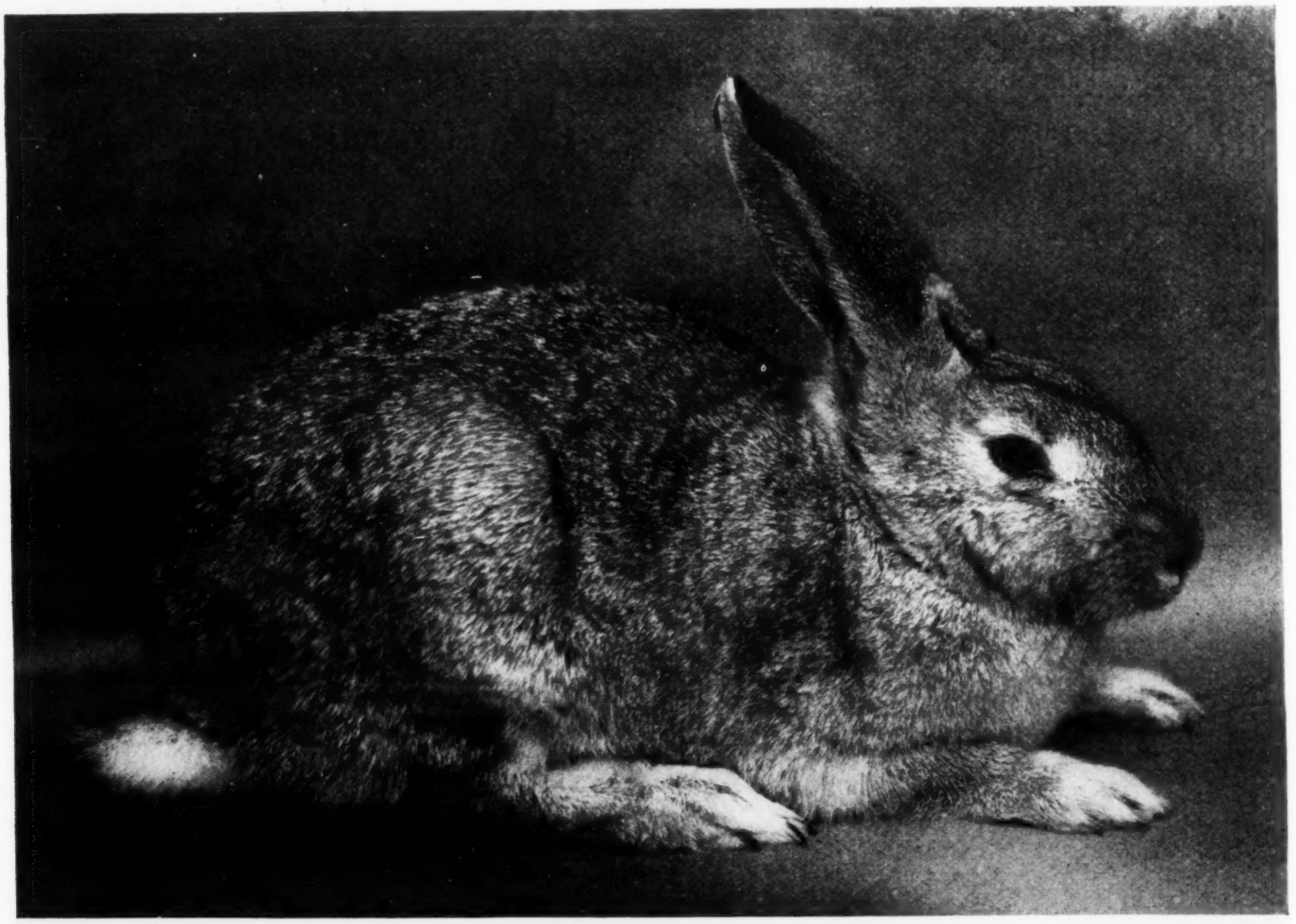
TO THE average person, a white rabbit is a white rabbit, with a snow white coat and pink eyes, suggestive of Easter cards and childrens' pets. But the well informed rabbit fancier knows that there are several varieties of white rabbits different in appearance, and the geneticist finds that these varieties are also very different in regard to the young which they produce in crosses, in other words, they are genetically distinct. The ordinary albino rabbit (Figure 9) behaves as a simple Mendelian recessive character in crosses with a colored variety. The young of the first hybrid generation are all colored and those of the second generation are some colored, others white, in the ratio, 3:1. The whites of the second hybrid generation are as pure in color as their white ancestor and breed as true.

There is another variety of albino rabbit known as Himalayan (Figure 10) in which the extremities are pigmented. It looks like a pure albino contaminated with color by a cross with a colored variety, but it can not be produced in that way. The Himalayan is another variant of the same bearer of heredity or "gene" as produces the ordinary albino, but it is a perfectly stable alternative variant, probably quite independent in origin. When ordinary



HIMALAYAN ALBINO RABBIT

FIGURE 10. The extremities only are pigmented, the coat elsewhere being white and the eyes pink. The formation of pigment is controlled by temperature, the extremities being dark colored because they are not as warm as the rest of the body (See text, page 219).



CHINCHILLA RABBIT

FIGURE 11. A third form (allelomorph) of albinism. The coat contains black pigment but no yellow.

albinos and Himalayans are crossed, they produce Himalayan young in the first generation and in the second, three Himalayans to one ordinary albino. Thus Himalayan is shown to be a dominant allelomorph of ordinary albinism.

A third variant of the albino gene is seen in Figure 11. This is not a white rabbit, but should be mentioned here because of its genetic connection with albinism. This variety, known as chinchilla, is pearl gray in color, differing from ordinary gray in that it contains no yellow pigment but only black. Ordinary gray (Figure 12), the color of wild rabbits, is a fourth variant of the gene which produces albinism. It is undoubtedly the original form of the gene, from which the other three have arisen as mutations. The one which departs most from the wild condition, complete albinism, was probably the first discovered. Certainly the one which departs least from the wild type, chinchilla, was the last to be discovered. It has become known only in very recent years, but is now one of the favorite fur breeds on account of its beauty.

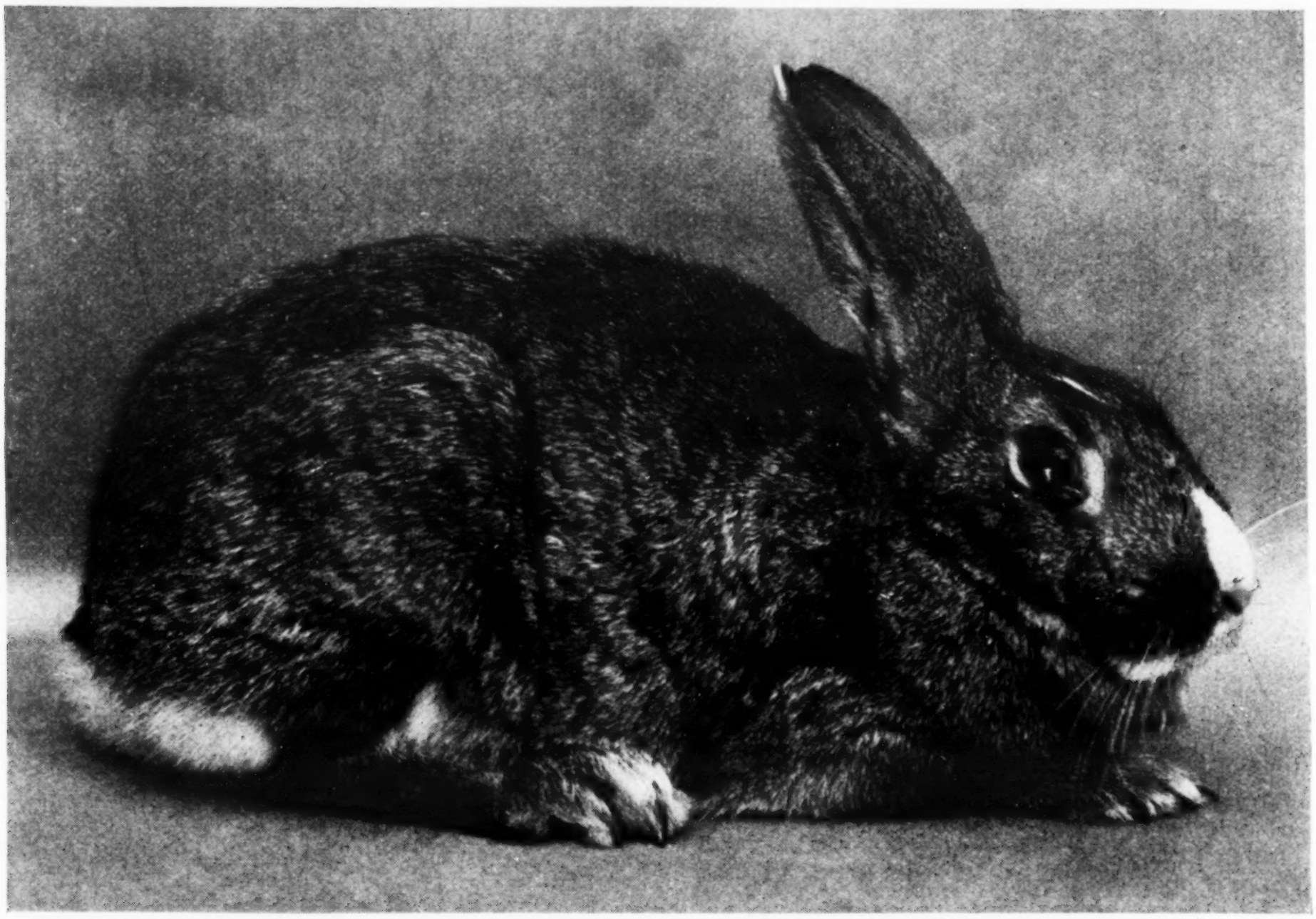
When any two of these four variants of the color factor are crossed with each other, the more heavily pigmented form dominates over the other, followed in later generations by segregation on a 3:1 basis. Thus the four are stable allelomorphs of the same gene. No one of them can be resolved into another, nor can any individual transmit more than two of them, though by suitable combinations individuals may be produced which transmit *any two* of the four. The series is a good example of what geneticists call "multiple allelomorphs."

In Figures 13 and 14 are shown two varieties of white rabbits, very similar to each other in appearance but very different in genetic properties. They have white fur but colored eyes. When crossed with each other they produce young of the wild gray type. See Figure 12. The result shows that they transmit different but complementary genetic factors.

The rabbit shown in Figure 14, although not an albino, owes its white coat to an albino allelomorph, chinchilla (Figure 11). Genetically it is a *yellow chinchilla*. It was produced in the second generation of a cross between yellow and chinchilla, and represents a recombination of those two recessive and wholly independent mutations. Yellow is a simple recessive to gray in crosses, as also is chinchilla. When yellow and chinchilla are crossed with each other, they produce in the first generation gray rabbits, showing that they are complementary variations from the wild type of coat. In the second generation four types are obtained, as would be expected from recombination of two independent factors. (1) Gray is the double dominant combination; (2) yellow is a single recesive, single dominant combination; (3) chinchilla the other single recessive, single dominant combination, and (4) white with colored eyes is the double recessive combination, which will breed true. Yellow is a variation in which no *black* is produced in the fur. Chinchilla is a variation in which no *yellow* is produced. Combining the two in a cross we have a variety which includes *no black, no yellow,* which amounts to white fur, though the eye retains the gray color of a chinchilla rabbit.

That such a white rabbit is genetically a "yellow chinchilla" is shown by two sufficient tests. (1) When crossed with yellow rabbits, it produces only yellow young, not gray as ordinary chinchillas do when crossed with yellow. (2) When crossed with chinchilla rabbits, it produces only chinchilla young, not gray as ordinary yellows do when crossed with chinchilla.

The rabbit shown in Figure 13 is neither an albino nor has it any genetic relationship with albinism. The variety is called Vienna white. It has a snow white coat, but the interior of its eye is colored. The front wall of

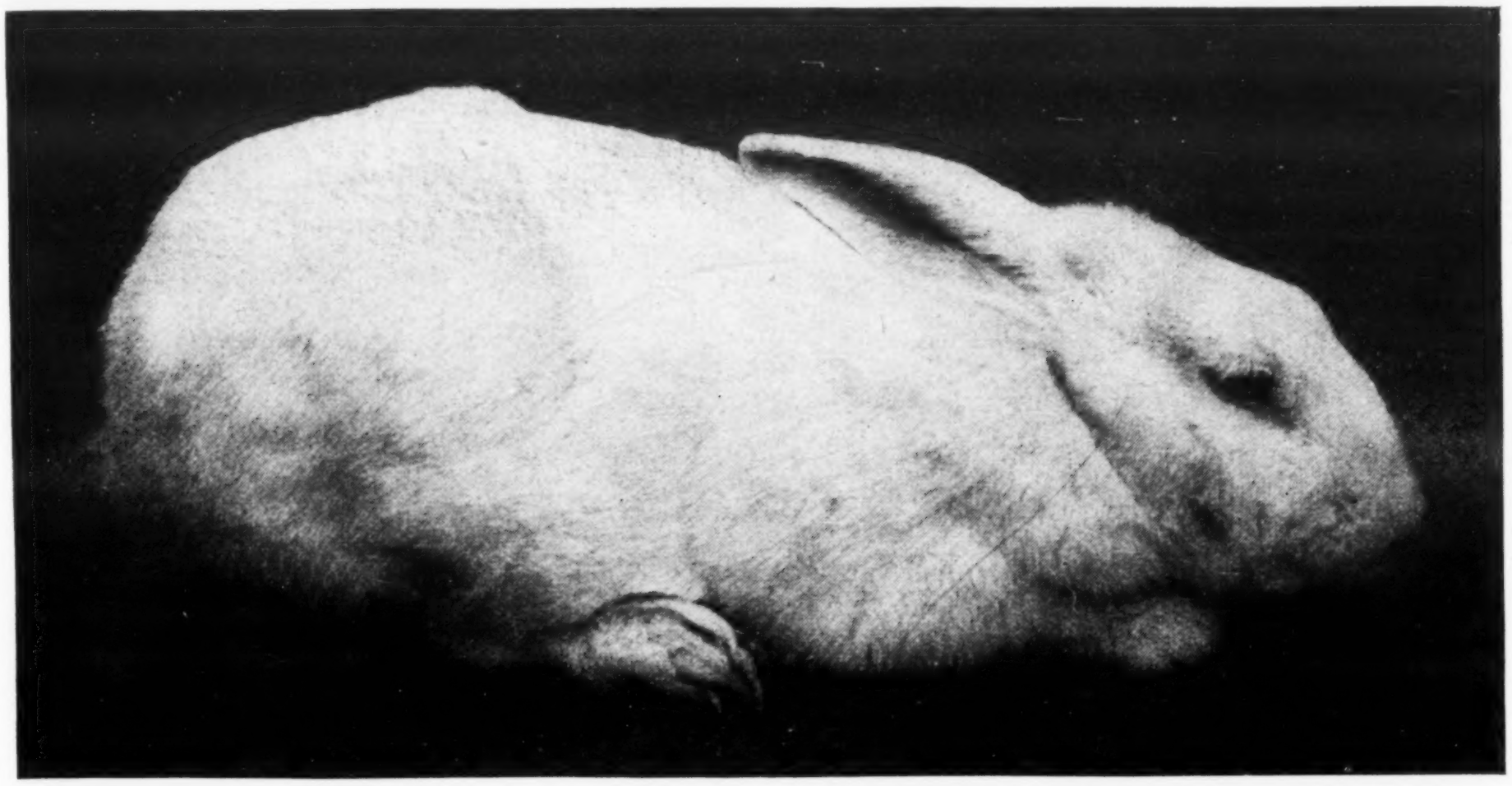


WILD TYPE OF RABBIT

FIGURE 12. His gray coat contains both black and yellow pigments. This fully colored condition is a fourth form of albino allelomorph, being the original type from which the other three arose as mutations. The parents of these rabbits were both white (See Figures 13 and 14).

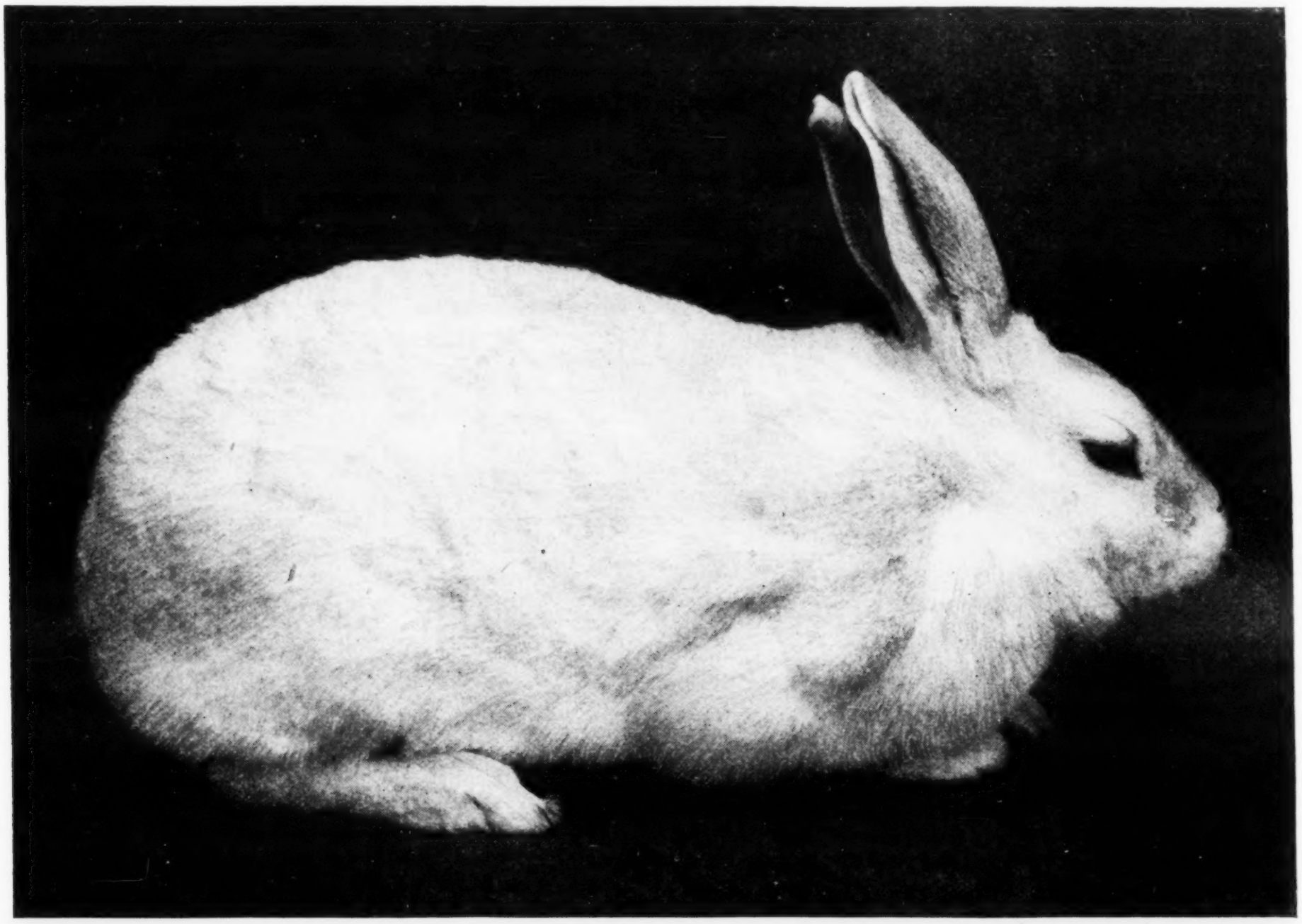
the iris, however, is unpigmented, so that the animal has what horsemen and dog-fanciers call a *wall eye*. When a Vienna white rabbit is crossed with a gray rabbit, gray offspring are obtained, and in the second generation three grays to one Vienna white. The character is thus seen to be a simple recessive dependent upon mutation in a single gene. When a Vienna white is crossed with an albino or with a chinchilla, gray young are obtained. One such is shown in Figure 12. It was produced by a mating of the Vienna white seen in Figure 13 with the white rabbit seen in Figure 14 (or to be perfectly accurate, her sister), she being, as we have seen, genetically a yellow chinchilla.

The young from this cross are gray like wild rabbits, which shows that Vienna white is a mutation genetically distinct from either yellow or chinchilla, the two mutually independent mutations which were associated in the other white parent to the cross (Figure 14). But the gray young from this cross usually show the presence of the Vienna white factor in the pigmentation of the eye, which may have a segment of the eye wall unpigmented, seen best on the front of the iris. The deficiency of pigment may also extend out into the coat producing a white blaze, white fore feet, and in extreme cases a well developed white belt over the shoulders, in which condition the animal resembles a Dutch marked rabbit. Vienna white accordingly is a mutation not as completely recessive as are the albino allelomorphs. But its segregation is wholly independent of them, so that we must conclude that it is not only physiologically different



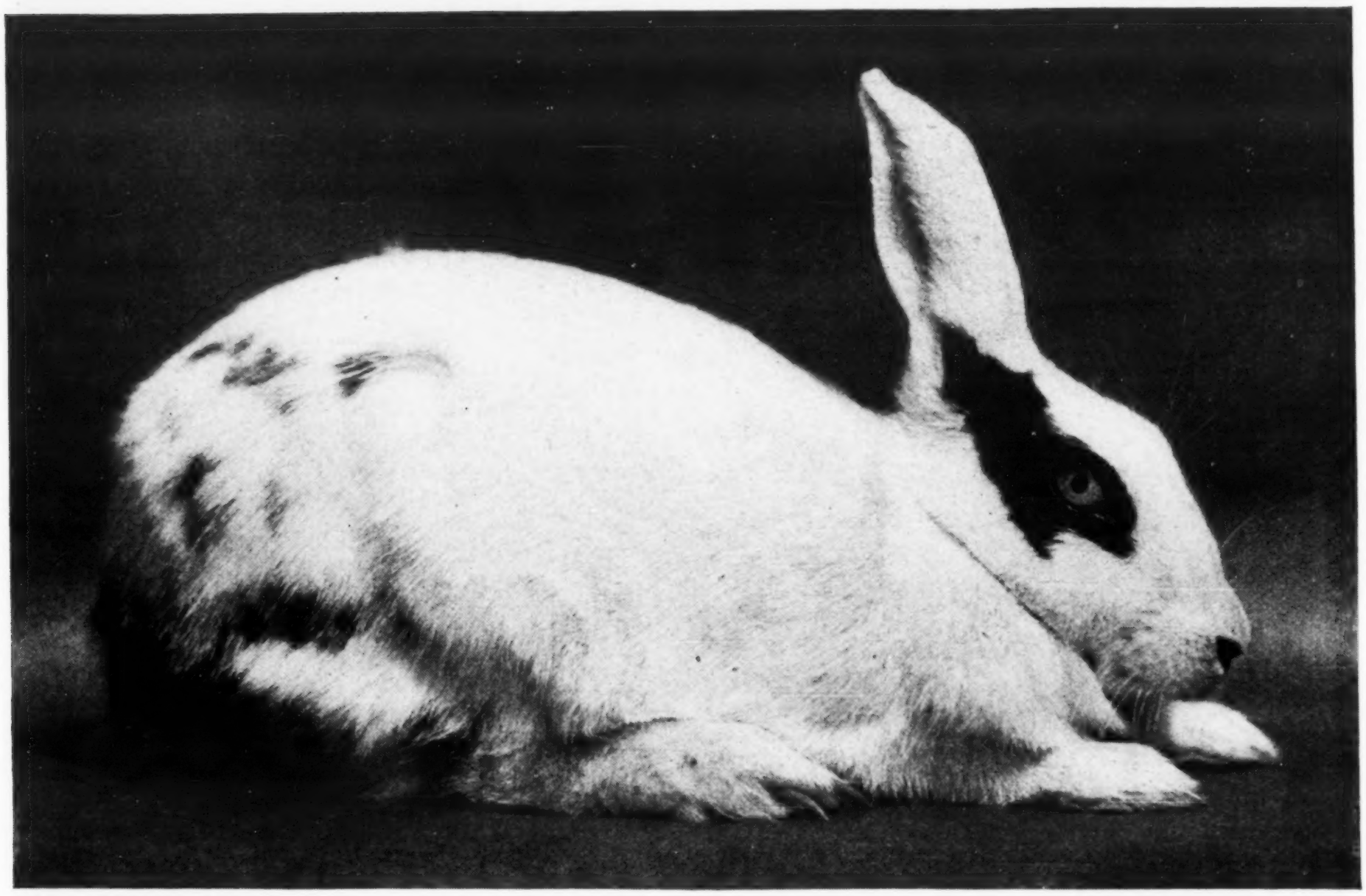
VIENNA RABBIT

FIGURE 13. This white rabbit differs from the true albino and the yellow chinchilla by having blue eyes. It is a simple recessive variation, different from any other known variety of white rabbit. This rabbit mated with a yellow chinchilla (Figure 14) produced the gray rabbit shown in Figure 12.



A YELLOW CHINCHILLA RABBIT

FIGURE 14. This white coated rabbit with grey eyes combines two different recessive color variations: (1) yellow (without black), and (2) chinchilla (without yellow). These rabbits are produced in the second generation of the cross between yellow and chinchilla.



DUTCH RABBIT

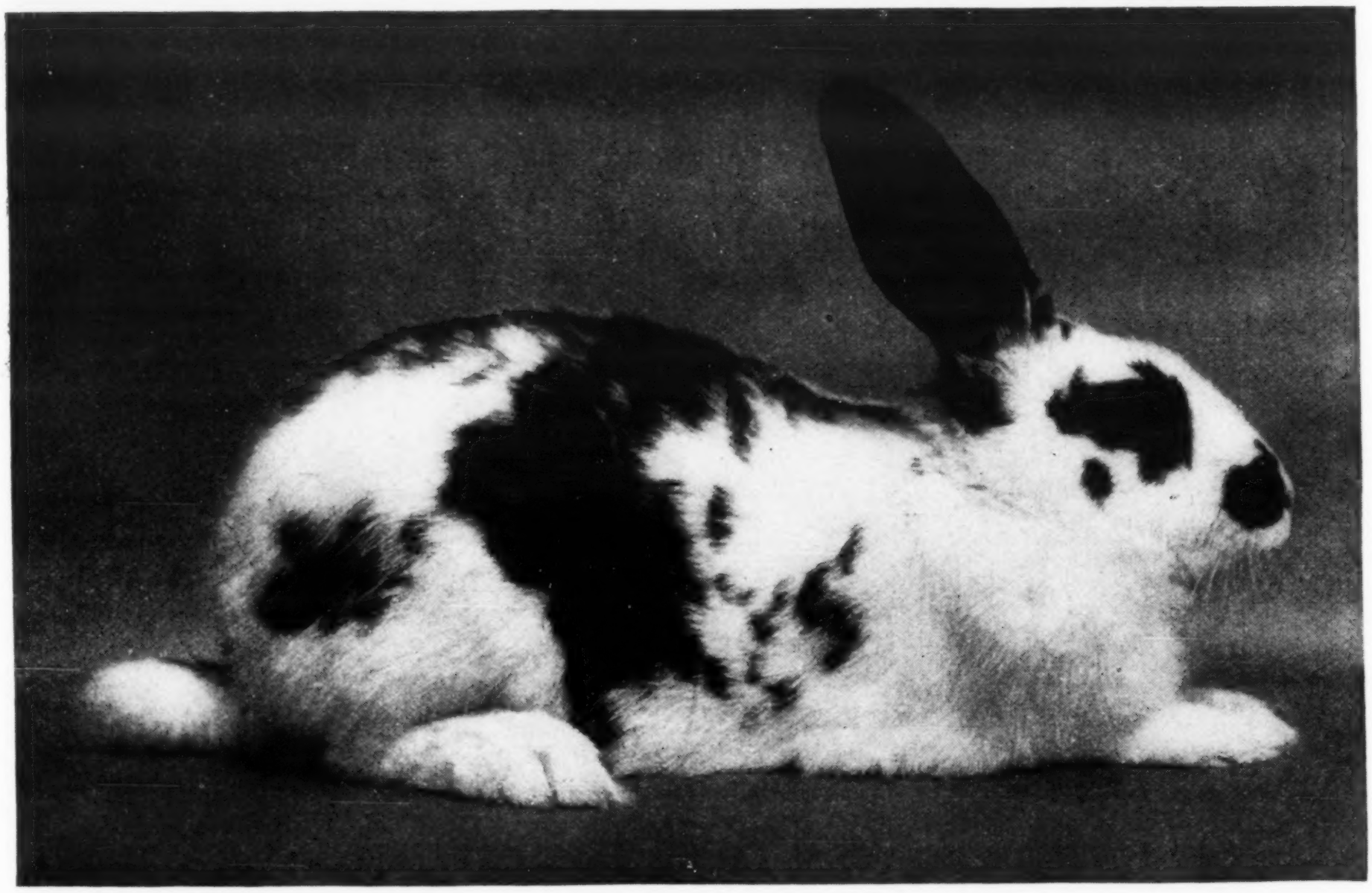
FIGURE 15. A true breeding type with coat largely white. Note the "wall eye" (unpigmented front of iris) which is found also in Vienna white rabbits.

from them but also that its gene is located in a different linkage system or chromosome.

We have already noted the resemblance of a rabbit heterozygous for the Vienna white character to a Dutch-marked rabbit. The resemblance is more than superficial. For both Dutch and Vienna white heterozygotes as a rule show some white in the coat and they show it in the same body regions and in the same type of markings, viz. white blaze and fore feet, culminating in a belt, with all the anterior half of the body white except a patch on either side of the head surrounding the eye. In the case of both, increasing whiteness affects the eye as well as the coat, a complete "wall eye" being found in the whiter heterozygotes of Vienna white as well as in the whitest races of Dutch rabbits. Note the "wall eye" in Figure 15.

Finally Vienna white and Dutch have coöperative rather than fully complementary genetic effects. Crossed with a Dutch rabbit, a Vienna white produces heterozygotes more extensively marked with white than are heterozygotes with unspotted (self) rabbits. But Vienna white and Dutch, while they are not opposed, are not identical in nature, since crossing the two does not produce an intermediate, but individuals more heavily pigmented than either parent. Their genes also lie in different chromosomes, since Dutch is genetically linked with both English spotting and angora coat, but Vienna white is genetically independent of both.

In contrast to Vienna white, English spotting (Figure 16) produces, in heterozygotes, white markings which are different in form and location from the white markings of Dutch rabbits. Again in contrast to both Vienna white and Dutch, English spotting is strongly dominant in crosses. Yet English and Dutch have coöperative



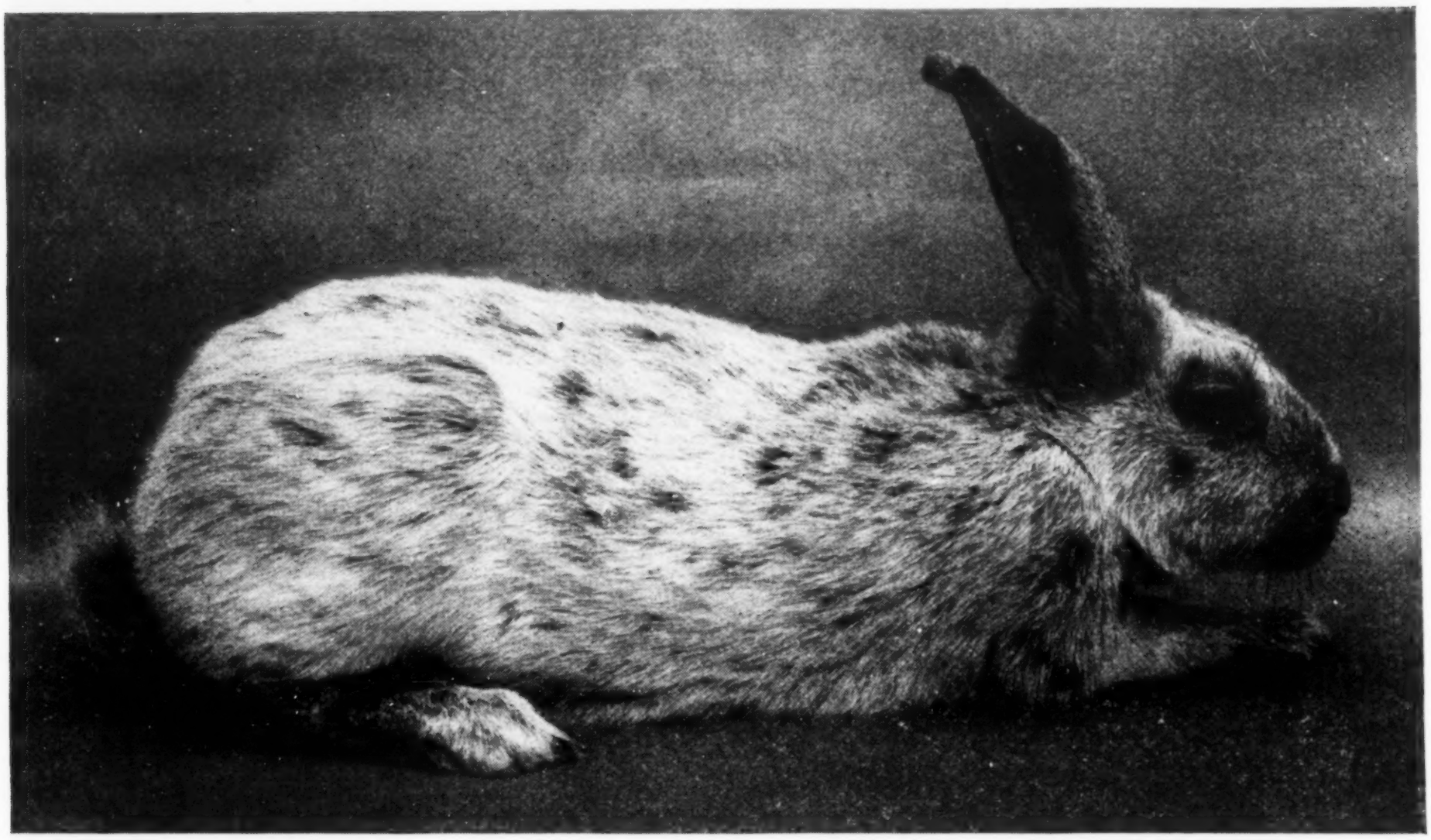
HOMOZYGOUS SPOTTED ENGLISH RABBIT

FIGURE 16. Although the coat is largely white the eye is always fully pigmented. This is a dominant mutation.

effects as also do English and Vienna white. English heterozygotes always show English spotting, but the colored spots are less numerous and extensive because of a whitening effect of either Vienna white or Dutch, when one of them is present in the heterozygote.

English spotting, notwithstanding its physiological differences from both Vienna white and Dutch and their resemblance to each other, is genetically independent of one and closely linked with the other. It is independent of Vienna white, but so closely linked with Dutch that it is impossible as yet to say whether the relationship is one of nearly complete linkage or allelomorphism. The experimental evidence shows conclusively that English and Dutch both lie in the same chromosome with angora coat, but indicates that Vienna white lies in a different chromosome.

There is another variety of rabbit which may be called white, only in the sense in which this term applies to a gray horse or a gray-headed man. This variety is completely white neither all over, like Vienna white rabbits, nor in spots, like Dutch and English rabbits. But the coat is *whitened* generally. This variety is called *argenté de Champagne* or "French silver." In the adult coat it is one of the most attractive of the fur breeds. See Figure 17. The young are born intensely black all over, like the colt of a gray mare, but at the first moult the new hair comes in with whitened or "silvered" tips. The silvering begins to show at about one month of age where the hair is shortest on the tip of the nose and on the feet. The juvenile coat has been completely shed at the age of three or four months and then the animal is white all over like our Northern varying hare in winter, but on parting the fur one finds that it is leaden blue at base. The character is strongly inherited, as animals of the uncrossed race breed true, but in crosses with other varieties the sil-



FRENCH SILVERED RABBIT

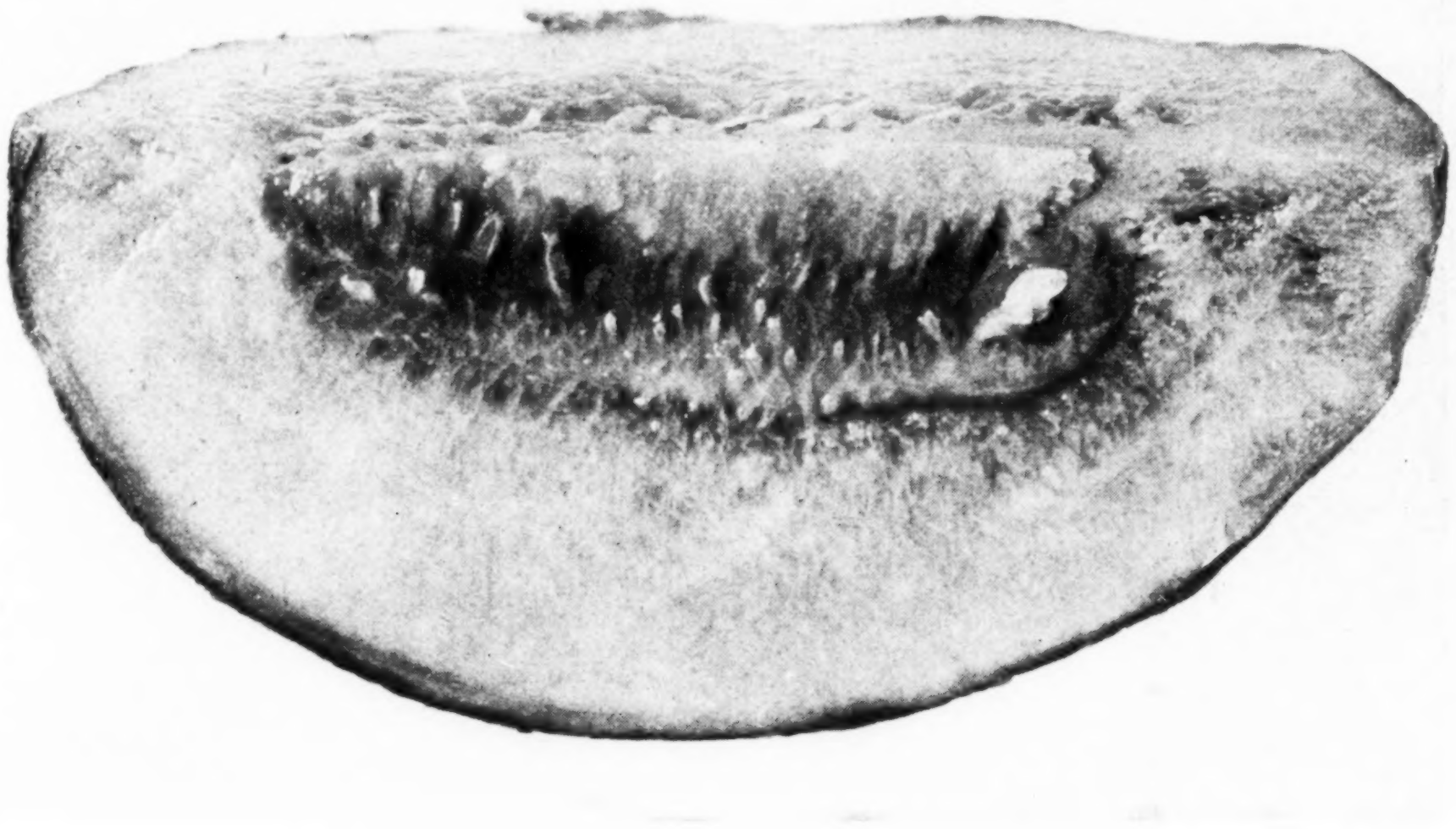
FIGURE 17. *The Argenté de Champagne* is one of the most attractive of the fur breeds. Its coat is not white but is whitened generally. The young are born coal black, but later acquire white tipped hairs and does the "varying hare" in winter.

vering behaves as a blending character, which seems to imply multiple factor representation in the germ-cells.

The similarity of this silvering to the winter coat of the varying hare suggests that similar agencies may be operative in the two cases. In the case of the varying hare, it is obviously cold that causes whitening of the hair tips in the autumnal moult. In the case of the silvered rabbit, it is perhaps the colder environment of the young as their second coat comes in that makes this coat white, whereas the first coat starting to develop in the embryonic period, within the mother's warm body, acquired full pigmentation.

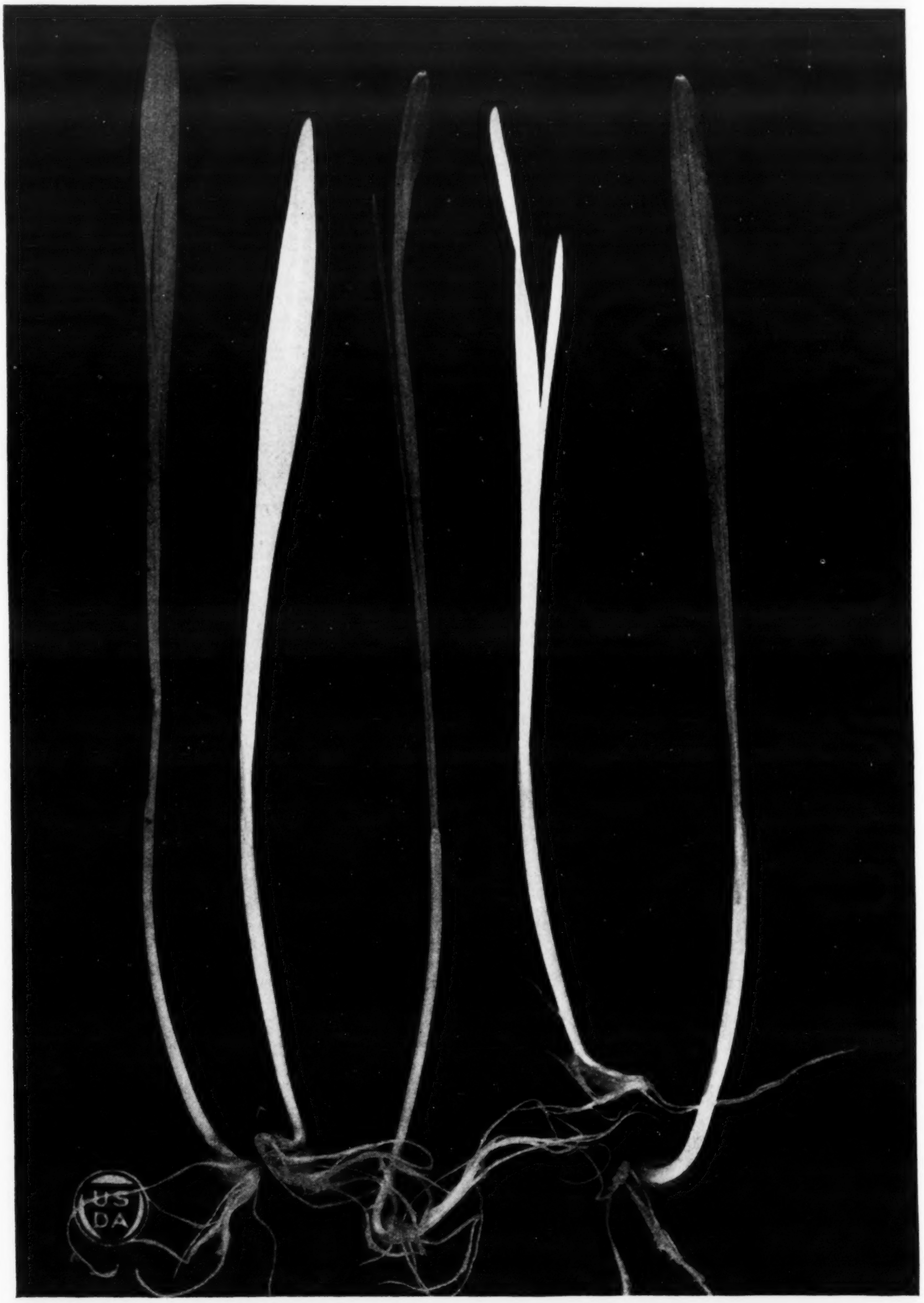
In the case of the Himalayan rabbit (Figure 10), there is also a difference in pigmentation between the first coat and later coats. Here also temperature appears to be a controlling factor, but the nature of the control is different. Himalayan rabbits are either white all over in their first coat, or occasionally show a slight sootiness of the hair, heaviest at the extremities of the body but not stopping abruptly as do the markings of the adult coat. A young one which gets chilled in the nest and yet survives, shows the darkest sootiness of any of the litter as regards the juvenile coat, though in its adult coat it may not differ from the others. For several years we tried by selection to produce a race which would regularly be sooty in the first coat. The best material for selection occurred in cold weather and it seemed that the best individual was generally the "runt" of the litter, which died. In summer the young were not very sooty and we did not seem to progress with the experiment, which was finally abandoned without our having discovered why we had failed. This has since become clear through observations made independently by two European investigators. They have shown that if an adult Himalayan rabbit has an area on its back, where the hair is unpigmented, shaved and the animal is then kept

in the cold, the new hair formed there will come in black like that of the extremities. Accordingly it seems to be the lower temperature of the skin of the extremities which makes the hair there regularly come in dark in the adult coat. But during gestation, when the juvenile coat starts to form, the extremities are as warm as the rest of the body and the pigmentation formed at that time is scarcely if at all heavier.



A Seedless Muskmelon

This melon was brought to the Department of Genetics of the University of Wisconsin, its previous history being unknown. The thick fleshy part was of a rich orange color, and when freshly cut the central portion, containing the abortive seeds, had much the same appearance, being relatively solid and showing very little of the fibrous, stringy texture of the ordinary melon. The dark appearance of the central area shown in the photograph, setting off the central part from the other, is the result of a watery infiltration of this part which developed after the melon was cut. There was no central cavity, as is shown by the continuous straight edge of the cut piece. No functional seeds were found. L. J. Cole.



ALBINO AND NORMAL BARLEY SEEDLINGS

FIGURE 18. The seedlings were photographed eleven days after germination, at which time the albinos have nearly reached their maximum size. When the food supply stored in the kernel is exhausted, the albino seedlings die, for the formation of starch by photosynthesis cannot take place without chlorophyll. Genetically, albinism in barley behaves as a simple Mendelian recessive, as it does in nearly every other plant and animal in which its inheritance has been studied.

ALBINISM IN BARLEY

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Washington, D. C.

ALBINO barley seedlings were first found by the writer in the cereal nursery at the Aberdeen (Idaho) Substation, in the spring of 1922. Four of these white seedlings were noticed in a F_3 head-row of the cross Nepal × Many-noded Dwarf*. These white seedlings died after about ten days because they lacked the necessary chlorophyll to carry on the photosynthetic processes. The remaining eight plants in the head row were of the normal green color and to all appearances were as vigorous and healthy as other plants in adjacent rows. Each of the normal plants in this row was harvested individually and the seed sown again the following year.

In 1923 it was found that four of these eight normal plants produced seedlings that were albinos. These results indicated that some of the plants of the previous year must have been heterozygous and that albinism was probably a recessive Mendelian factor. The forty-four normal plants in the rows throwing albino seedlings again were harvested individually for further study.

During the winter of 1923-1924, populations of each of the forty-four plants were grown to the seedling stage. Large Petri dishes, containing moist absorbent cotton as a substratum, were used for this purpose. Figure 18 shows the difference between albino and normal seedlings eleven days after germination. Out of the total number of forty-four plants tested, seventeen were found to breed true for the normal green color and twenty-seven segregated, producing green and albino seedlings. On the basis of the expected 1:2 ratio 14.7 plants should breed true and 29.3 plants should segregate. The actual numbers are in very close agreement with the theoretical.

Seedlings grown from the twenty-seven heterozygous plants gave the following segregation, compared with the expected:

	Normal	*Albino*	*Ratio*
Actual	580	194	2.99:1
Expected	580.5	193.5	3:1

The results show that albinism in barley behaves as a simple Mendelian recessive. On the basis of a 3:1 ratio the agreement between actual and the expected number of normal and albino seedlings is very close. Kalt[1] and Vestergaard[2], in their work with barley albinos, found that inheritance of this character followed a 3:1 ratio, and thus, is in accord with the results reported in this paper. Nilsson-Ehle[3] reports results showing both 3:1 and 9:7 ratios for the albino character when different varieties were used in hybridization.

A microscopical study was made of the endosperm starch of both normal and albino-producing seed. For this purpose individual seeds were cut in half, the distal end tested, and the embryo end germinated to determine its phenotypic expression. Starch grains from both types of seeds, when stained with iodine, were identical, to all appearances. No defective endosperms could be found in either the normal or the albino-producing seedlings.

Albino seedlings are not of infrequent occurrence in ordinary barley fields. In the spring of 1923 observations were made on the varietal plats at Aberdeen. White seedlings were found to average about three or four per plat.

*This dwarf and cross are described in detail by Harry V. Harlan and Merritt N. Pope in *Journal of Heredity*. 13:269-273. 1922.

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Happy Wedded Life

Happy Wedded Life, by A Practicing Physician. Price $1.00. The Better Health Publishing Company, Washington, D. C. 1924.

This unusual booklet written by a physician of thirty years experience consists largely of advice to married couples. A concise presentation of facts upon this subject by a medical authority would be considered a step in the right direction but the omission of the author's name from the publication must raise considerable suspision concerning the sincerity of its contents.

The theme of the subject matter is based on the existence of positive and negative "life currents." Using this as a foundation, directions are given to aid single people to find a mate, rules for obtaining the maximum of bliss from married life, and formulae for determining the sex of the children. The portion on sex determination, which contains specific directions for obtaining the desired sex at will, would be of considerable interest if it contained some original data to substantiate the claims made. The directions for obtaining the sex desired are based on three theories: the Thury theory; the Dawson theory; and the Reed theory of lunar influence. The author's directions are as follows: "Apply the Dawson theory by figuring as to the sex of the ovum by months, and plan, also, for sexual union at the proper time of the month, the Thury theory; and third, plan for sexual union at the proper time of the moon's influence during the 24 hours. All three of these theories can be combined for use. To this should be added an earnest request to the unseen helpers, including one's higher self, to aid in securing the desired sex." The appeal to the "unseen helpers" indicates that the author has some doubt concerning the effectiveness of the methods in all cases.

The matter of references and citations is to be justly criticised in that only those favoring the author's views are given. A presentation of some of the results of recent research upon sex determination including a discussion showing wherein they agree or disagree with the hypothesis given, would have been a valuable addition. It is almost needless to say, however, that anyone who is informed upon the results obtained in the scientific investigation of sex determination during recent years cannot, in the absence of data, place any confidence in such a combination theory of sex determination.

H. C. M.

Note:—"In the 18th century Drelincourt, according to J. A. Thompson, had collected 262 groundless hypothesis concerning the determination of sex, and Blumenbach made the sarcastic comment that Drelincourt's own theory formed the two hundred and sixty-third. There have, of course, been others since Drelincourt's day." Holmes, S. J. *Bibliography of Eugenics*, p. 477.

Editor.

EUGENICS IN GERMANY

FRITZ LENZ

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I HAVE been asked by the JOURNAL OF HEREDITY to describe the development and present status of eugenics in Germany; and I accept this invitation the more gladly, because I hold that eugenic cooperation of all nations of European race and civilization is urgently needed. The existence of the best racial elements of all these nations is already more or less directly threatened.

The leading German eugenic organization, the German Association for Eugenics (Deutsche Gesellschaft fuer Rassenhygiene) outlined its views and objects in 1922 in a series of "theses" which were translated in the JOURNAL OF HEREDITY (XIII, No. 8). I need not, therefore, discuss the fundamental principles of German eugenics—so far as I can see, they are in complete agreement with those of Anglo-Saxon eugenics. I will, instead, try to give some idea of the developmen of eugenic knowledge in Germany, together with the progress of its propaganda and its application.

Early Eugenists

The starting-point of eugenic doctrine in Germany is a book which Alfred Ploetz published in 1895 under the title, "*Foundations of a Eugenics. Part I, The Efficiency of our race and the protection of the defective.*" Ploetz, who was born on the coast of the Baltic (in Swinemunde, Pomerania), in the early eighties studied social economy in Germany, and subsequently medicine in Switzerland. A strong impulse to work for the bettering of the relations of men to each other led him into the socialist camp in his youth. But he soon recognized that a genuine and lasting improvement of the human race is not to be attained by changes in economic relations alone, and he began to think in terms of eugenics.

He knew the work of Darwin, Wallace, and Haeckel, and was also acquainted with the eugenic thought of Plato and Lycurgus, in antiquity; Galton's pioneer work, however, was unfortunately not known to him at the time. If he had had knowledge of Galton's writings, German eugenics would have been saved from some missteps.

After Ploetz had, in the early nineties, spent some years as a practicing physician in the eastern United States, he returned to Germany, to devote himself entirely to eugenics. But as the word "eugenics" was unknown to him, he gave the name of "Rassenhygiene" to the study of the best conditions for the maintenance and development of the race. The word means exactly the same as the word "eugenics" which Galton introduced; it is therefore best translated into English not "race hygiene," as seems to be customary, but simply "eugenics."

In his book of 1895, Ploetz described the general factors of evolution so far as the status of the science of biology at that time made it possible. In his theoretical views, he stood for the most part with the great German theorist of heredity and selection, August Weismann; like the latter, he particularly departed from the then widespread idea of an "inheritance of acquired characters." Ploetz understood the danger of a weakening of natural selection, and its contra-selective (dysgenic) action. He also had a clear and full realization of the danger of excessive limitation

[1]Translated by Paul Popenoe.

of births—a realization largely brought to him through his medical practice in New England. He noted in particular that the Anglo-Saxons of America would be left behind, unless they adopted a policy that would change the relative proportions of the population. The practical measures suggested in Ploetz' book were largely shaped by an endeavor to harmonize eugenic objects and socialistic doctrines, though a solution of this conflict was not wholly found.

After Alfred Ploetz, the chief founder of eugenics in Germany is Wilhelm Schallmayer. Born in Mindelheim, a small city in the Swabian part of Bavaria, he, too, first studied social economy and then medicine; and for many years he practiced as a physician. In the year 1891 there appeared a pamphlet which he had prepared five years before, *"On the menacing physical deterioration of civilized man."* At that time he perceived the great danger of the limitation of natural selection: he missed the meaning of the even more serious contra-selection (dysgenic selection). Moreover, in this first publication he followed the Lamarckistic thought of the time, in accepting the "inheritance of acquired characters." Hence he saw only the danger of bodily degeneration, and not the much greater danger of mental deterioration. This first publication of Schallmayer's, therefore, can not take rank with that of Ploetz. He, too, was unfamiliar with the work of Galton. Later (in 1903) Schallmayer published a work that was for many years the best German exposition of eugenics: *"Heredity and Selection in the Life of Peoples."*

The external cause for the appearance of this book was a prize offer made in 1900 by the steel magnate F. A. Krupp, for a work on the subject, "What can we learn from the theory of evolution, for the internal political development and legislation of nations?" The motive of the offer was political, not eugenic; Schallmayer, however, who answered the question in terms of eugenics, won the first prize. As the judges were three prominent German scholars, Schallmayer brought eugenics in this way to the attention of the world of scholarship in the country. He worked his prize essay over and improved it in successive editions, of which the fourth had appeared at the time of his death in 1919.

But if the path of eugenics in Germany was blazed by Ploetz and Schallmayer, it was foreshadowed by individual German scholars, at a much earlier period. Even in the eighteenth century a German professor of medicine, Johann Peter Frank, had developed the eugenic point of view and published it in a work that appeared after 1779 in several volumes. *"A System of Complete Medical Policy."* Frank therein showed that mankind had undergone a widspread degeneration, and that this was the result of no irremedical senescence, but that it could be checked by appropriate measures, and the health and strength of the race brought back again to normal. Frank even recognized the danger of birth control. We learn from his book that even in those days there were cities where the well-to-do burgers were unwilling to have more than two children in a family. "This custom and the other causes of depopulation warn us of the future fate of Europe." Frank desired not merely a quantitative population policy, however, but a qualitative one. He had learned the great importance of heredity in the causation of various diseases, and demanded that the marriage of epileptics, insane, consumptives, and other defectives be forbidden; on the other hand he urged the adoption of measures to encourage the reproduction of sound and capable persons; in short, he laid the framework for a thoroughly systematic policy of eugenics.

Unfortunately his thoughts were

denied any practical application. His book had indeed a fairly wide sale, and he was looked on as one of the best medical authorities of the time; but his contemporaries apparently did not grasp the importance of his eugenic teachings.

In 1802 the Mannheim physician Mai took up Frank's suggestions and embodied them in a well-drawn legislative bill. The government of the Rhine Palatinate, to which Mannheim then belonged, referred it to the medical faculty of the University of Heidelberg and the Medical Council of Mannheim, both of which bodies approved of it as sound and practical. But the Palatinate was invaded about that time by a foreign army. The politically disrupted German people could not cope with it; and the political and economic distress which followed prevented any attempt to put the eugenic plan into execution. Frank's important eugenic efforts therefore have no historical continuity with those of the present day. His eugenic writings have been sought out afresh in recent years.

Other German thinkers had from time to time arrived at eugenic conclusions: thus Kant, the greatest of the German philosophers, who was of course familiar with Plato's eugenic ideas, in the second half of the eighteenth century. Going back to Plato, the German philosopher Schopenhauer, in the first half of the nineteenth century, also stressed the fact that "only through generation" (i.e., eugenics) is it possible really to elevate the human species. In the second half of the nineteenth century the poet-philosopher Nietzsche grasped, with all the vigor of his sensitive spirit, the danger of a decline of the race, and set up the ideal of better breeding as the central point of his teaching. In one of his latest writings (1888) he urged medical certificates before marriage, segregation and sterilization of the unfit, and other eugenic measures. Nietzsche, who had a real influence on the German mind at the end of the century, undoubtedly helped to prepare the way for a victory of eugenic ideas.

At the end of the nineteenth century Schemann's translation gave wider circulation in Germany to the book of the French diplomat and writer Gobineau *on the Inequality of Human Races*. His idea of the greatness of the Nordic race has, for easily understandable reasons, made much more impression in Germany than in France.

In a similar spirit Otto Ammon wrote, in 1893, a book on natural selection as applied to man, and in 1895 another on the biological foundations of social organization.

Ludwig Woltmann supported Gobineau's doctrines even more strongly; he issued a *Political Anthropology* in 1903 and in 1905-7 two books on the historical record of the Nordic race in France and Italy. These books deserve mention in this connection, because the growth of an appreciation of the Nordic race tended to promote interest in eugenics. Indirect results also came from a book by the eminent historian Otto Seeck in which (1895) *The Downfall of the Ancient World* for the first time was explained by the action of dysgenic influences.

Existing Eugenics Agencies

In 1904 Ploetz founded the *Archives of Race- and Social-Biology*, that remains today the leading serial publication in Germany in the field of Eugenics. In 1905 he organized an International Society of Eugenics, of which the German section was the German Eugenics Society. By this route eugenic organization reached Scandinavia, where Lundborg in Sweden and Mjoen in Norway, in collaboration with Ploetz started eugenics societies.

The eugenics movement in Germany took a great step forward when an excellent eugenics exhibit was set up at the International Hygiene Exposition in Dresden, 1911, principally

through the efforts of Max von Gruber, the first professor of hygiene in Germany, who had fully recognized the meaning of eugenics, and of Ernst Ruedin, a pioneer in the study of the inheritance of mental disorders. In 1913 Geza von Hoffmann, formerly an Austro-Hungarian consul in America, made German students acquainted with the development of eugenics in the United States through a well-known book. In the same year Gruber gave, at the annual meeting of the German Public Health Association (the most important German organization in that field) an influential address on the falling birth-rate, in which he examined this phenomenon in the light of eugenics.

Notwithstanding all this, the most widespread views of population remained quantitative. Even the theses of the German Eugenics Society, adopted at its 1914 meeting, gave only nominal adhesion to the true eugenic point of view. These theses were therefore quite properly supplanted by the more logical and far-reaching theses of 1922, which were reproduced in the JOURNAL OF HEREDITY.

During the World War the eugenics movement in Germany stood entirely still; political anxieties and the effort to protect the immediate existence of the nation, as of each individual, absorbed all strength and thought. In the first years after the war, the revolution and the general misery were not favorable to eugenic works. On the other hand, the horrors of war and revolution had given to many a greater vision of the decline of their race and the necessity of eugenic measures. A fourth of the young manhood of Germany remained on the battlefield; another fourth, although surviving, was badly hurt in mind or body. Encouraged and supported by an enemy outside, Bolshevism spread inside the commonwealth.

It is not strange, then, that a baffled and fatalistic spirit has manifested itself here and there. On this spirit an unsound and unscientific book by Spengler. *The Downfall of the Occident,* the first edition of which appeared in 1918, has made a much greater impression than it could have done in quieter times. Spengler predicts the downfall of the Occident (that is, of European civilization), not because of racial degeneration through dysgenic influences, but because the predestined duration of western civilization is supposed now to have reached its end. It must be admitted with regret that this book, so lacking in eugenic understanding, has made a much wider impression on the educated circles of Germany than eugenic doctrines have hitherto been able to do. Nevertheless it may be hoped that even Spenglerism can be turned to the profit of eugenics: the question of the downfall of western civilization has been made timely, and the ground has perhaps thus been prepared for a scientific investigation of the causes and prevention of such a downfall.

It is a good symptom that in the Department of Public Welfare of the Prussian government a scientific council for eugenics has been established. Eugenics is thus officially recognized as a factor that must be taken into account in legislation. This council on eugenics, which is composed merely of private citizens whose titles are purely honorary, and which can not actually make laws itself, has however not shown much activity so far. But the eugenic point of view spreads, and that is the main thing.

In 1921 the German Public Health Association invited the hygienist Professor Ph. Kuhn to make a report on the problems of eugenics, and although his proposals were—according to German ideas—far-reaching, they met with general approval. In 1922 the largest and most influential scientific association of Germany, the Association of German Naturalists and Physicians, celebrated its hundredth anniversary with three lectures

on heredity; and the writer of this article, who was invited to speak on human heredity, was able, with the warm approval of the meeting, to insist on the need for eugenics. In the same year the German Eugenics Society adopted its new theses, which now form the program for eugenics in Germany. The society now has local groups in Berlin, Munich, Freiburg, Stuttgart, Dresden, Bremen, Tuebingen and Kiel. The president this year is Dr. Krohne of Berlin. Unfortunately the society has had to meet great financial difficulties; it has not even been able so far to employ a paid secretary; and people who have both time and energy, after earning their own living, to give aid to the society in its work, are of course scarce, particularly in present-day Germany where even the most industrious in his own profession can hardly make a living.

In German Austria eugenics societies have recently been established in Linz, Graz and Vienna.

The very satisfactory spread of genealogical societies, which has been a marked feature in Germany during recent years, will benefit eugenics at least indirectly.

In 1921 a German Genetics Association was founded. At its meetings eugenics receives attention, as well as theoretical problems of heredity and development.

Bavaria, in 1923, became the first of the German states to establish a university chair of eugenics. There was indeed no money for a new professorship; but as Germany's enemies had deprived her of her tropical colonies, a chair of tropical hygiene was converted into a chair of eugenics, and the writer of this article was invited to occupy it. There has been a professorship of human heredity in Berlin for several years; its occupant, Heinrich Poll, devotes some of his attention to eugenics. In Munich the Psychiatric Clinic has an annexed genetics laboratory whose director, Professor Ernst Ruedin, is occupied with the study of the inheritance of mental disorders. The Anthropological Laboratory of the University of Munich, directed by Professor Rudolf Martin, has a section on the study of the family, in charge of Dr. W. Scheidt. All of these institutions are regrettably handicapped by inadequate finances.

Things are little better in Switzerland. There is a foundation, established by Julius Klaus, for the study and promotion of eugenic reforms, particularly through the encouragement of scientific researches. The support of eugenic projects is under the direction of the anthropologist, Professor Otto Schlaginhaufen of Zurich. Klaus, a man weak and sickly from birth, devoted his entire property to the end that other men might have more fortunate birth. In Switzerland, too, the medical researches of Dr. E. Hanhart are particularly directed to human heredity.

In Germany, likewise, medical studies in heredity are making steady progress despite the hard times. Among those who should be mentioned are Dr. W. H. Siemens of Munich, whose studies in the inheritance of skin diseases are noteworthy; Professor W. Weitz of Tuebingen, who has specialized on the inheritance of internal diseases; and the Stuttgart physician and statistician, W. Weinberg, has made studies covering a wide range. A woman, too, Dr. Agnes Bluhm of Berlin, has played a worthy part in eugenic research and propaganda, and has particularly helped to spread a eugenic point of view among her own sex.

Since genetics became a fashionable study, it has attracted many people who are more active than scientific, and who seek in it a "career" more than anything else. Many publications have therefore to be looked at with great caution. So far as I have been able to judge from the literature

that reaches me, the same state of affairs exists in America.

Socialism and Eugenics

In any case, genetics and eugenics have made good progress in Germany. The well-known hygienist, Professor Max von Gruber, sees in eugenics the heart of all social and hygienic measures. The professor of social hygiene at Berlin, Alfred Grotjahn, has also taken a firm stand for eugenics—a stand that is all the more conspicuous because he belongs to the Socialist party and owes his position to the revolution. He has gone so far as to urge that socialism should follow the aspiring young science of eugenics. If one may recall that the founder of modern socialism, Marx, traced all evil to economic conditions and expected all good from an overthrow of economic conditions, and that the Socialist principles can in reality never be harmonized with the actual inherited differences among men, this espousal of eugenics by an influential leader in the party that at the present time is the strongest in the country, must for every reason be welcomed.

Not less acceptable is the fact that leading circles of the Catholic church —one of the most important spiritual powers in Europe today—begin to appropriate eugenic ideas.. The Jesuit Hermann Muckermann has pioneered here with an effective book called "Child and People," that has already been distributed by tens of thousands. This series of lectures was attended by thousands of hearers, thus Galton's hope, that eugenics might become a factor in religion, is in our day in a way to be realized.

As a sign of the growing interest in eugenics I might here mention that a textbook of human heredity and eugenics,[2] which the writer published in 1921 in collaboration with the botanical genetist Erwin Baur and the anthropologist Eugen Fischer, was sold out within a few months, in spite of the hard times, and had to be immediately followed by a second edition. H. W. Siemens' textbook of human genetics, which also gives the fundamentals of eugenics and was prepared particularly for physicians, has also had a second edition. In many books of a more general nature one will find chapters on engenics, as in the great *Handbook of Hygiene*, in many volumes published by Rubner, Gruber and Ficker in **1923**, where a special section is given to the subject. A widely known, short textbook of hygiene by Prausnitz also has chapters on eugenics. Even a *Handbook of Obstetrics and Gynecology*, by Halban and Seitz, has a section on the topic. The *Archiv fuer Rassen und Gesellschafts-Biologie*, issued by the publisher J. F. Lehmann in Munich, has had to cope with great financial difficulties, since in Germany nowadays there are few "intellectuals" who can afford to subscribe to periodicals; but its further appearance has been assured. It prints original articles in the fields of heredity and eugenics, and also critical notices of new books and periodicals. Besides this, there is an *Archiv fuer Frauenkunde und Eugenetik*, edited by a gynecologist in Berlin, Max Hirsch.

In **1922** a richly illustrated book by Hans Guenther, entitled *Rassenkunde*,[3] appeared. It is in the same spirit as Madison's Grants American book, "*The Passing of the Great Race*." Like the latter, it is not purely scientific; yet it is to be welcomed from the eugenic side, for the exaltation of the Nordic race is eugenically advantageous. It has made a great impression in Germany, and I may be permitted to hope that it will do something to clear away the difficulties that have hitherto existed between the continental Germans and the related Anglo-Saxons.

[2]Bauer, E., Fisher, E., and Lenz, F. Menschliche Erblichkeitslehre und Rassenhygiene. Second enlarged and revised edition. Munich, 1923. J. F. Lehmann's Verlag.

[3]3rd edition, 1923, J. F. Lehman's Verlag, Munich.

"Race Hygiene" and "Eugenics"

There is a school of eugenists in Germany that becomes highly indignant every time the differences between the great races of the world are mentioned in connection with eugenics. These eugenists, mostly either Jews or Jewish partisans, therefore oppose the use of the word "race hygiene"; many of them, in deed, are extremely hostile to the mere mention of the word "race" in any sense. Thus it has come about that the Jewish or Jew-influenced eugenists of Germany speak of themselves as eugenists or eugenetists; the German eugenists on the other hand call themselves "race hygienists"—a fact that Anglo-Saxon eugenists may be interested to know. A large part of the German literature on heredity and eugenics is written by Jews, and thus it happens that Lamarckistic notions of an "inheritance of acquired characters" are often spread in the press, because most Jews have an emotional bias in this direction, being thus able to believe that racial differences are unimportant, since they can be obliterated by the action of one's surroundings. Hand in hand with this attitude one usually finds a disposition to deny the influence of selection.

At this point the influences that are working against eugenics in Germany might be noticed. While the leading genetists of Germany are collectively out of sympathy with Lamarckism, Oskar Hertwig a Lamarckian biologist, whose period of scientific activity was in the Nineteenth Century, allowed himself the publish in 1918 a paper in which he attacked Darwinian selection as an unfounded error and condemned eugenics based on it as a great danger to civilization. Among other things, Hertwig in this paper gave currency to the allegation that a colony for polygamous human breeding had been established in Germany and stocked with a carefully selected herd of 1000 women and 100 men. This fairy tale was unfortunately reprinted abroad, as for example in the *Eugenics Review*, evidently because no one presumed to question the authority of Oskar Hertwig. It is, of course, obviously false; anyone who knows even a little about conditions in Germany knows that polygamy is legally impossible and that the police would never allow such a colony to exist, even if it were projected. Other lesser lights who follow Oskar Hertwig and have undertaken a campaign against eugenics, need not be mentioned here.

Lectures on eugenics are delivered not only in Munich but in other German universities; usually a professor or privatdozent of hygiene takes up this line. Eugenics has nowhere yet been made a required study, and until that is done, one can hardly expect to find hours in the week when the students already loaded down with required courses (ten hours or more a day) can get time to attend lectures on this subject. Efforts must be made to have eugenics adopted as a required subject, not only for the medical profession, but for teachers, social economists, and all other intellectual careers that have to do with the building of the nation.

So far there has been no teaching of eugenics in the public schools; but it is possible for instructors in biology to adopt a eugenic point of view. In the higher schools two hours are set apart each week, during several years, for instruction in biology. As the material for this course is not prescribed in detail the teacher is free to incorporate eugenics if he desires.

Eugenic Legislation

In a legislative way practically nothing has yet been done among us There are no marriage restrictions in Germany. The only measure that has hitherto had any connection with eugenics is the requirement, since 1920, that on publication of the banns the official concerned must give to the

prospective marriage partners a leaflet calling attention to the importance of medical examination and advice before marriage. Even though this measure regularly comes too late, it has a certain educational value on public opinion.

Eugenic sterilization has not yet been practiced.[4] Some jurists take the position that it is forbidden by law, as "bodily injury"—a position that does not seem to be tenable. Eugenic termination of pregnancy is unfortunately not yet permitted, since the law makes no exception to the illegality of such operation, except when the mother's life is in immediate danger. Segregation of the mentally defective and criminal has hitherto been practiced only on medical and penal, not eugenic, grounds. Dissemination of a knowledge of contraceptives has not been made a crime in Germany, and I believe this is eugenically advantageous; for the disproportionate decrease of births among the superior part of the population could not be stopped by such means, and the prevention of conception among the intellectually inferior is eugenically desirable; and the eugenist must be able to offer to dysgenic couples a means of avoiding childbearing.

The eugenic point of view has not yet been fully adopted in tax legislation or in fixing the salaries of officeholders. It is true, there are increases for the latter, with the size of family, but as these allowances have been made (on socialistic principles) equally high for all, they rather work dysgenically.

The income tax is also applied dysgenically; in many cases two people married to each other must pay more tax than if they were single but living together in an illegal union.

The high inheritance taxes introduced by the socialistic revolution, which might rather be described as the confiscation of large estates on the death of their founders, have also operated dysgenically so far, because the number of children concerned is practically disregarded. And yet a really eugenic basis for inheritance taxation would be of great value in maintaining the race. Families with three or more children ought to be exempted from all such taxation; whereas, in families of only two children or a single child, one-third or two-thirds of the estate should revert to the nation. If the Americans would adopt such a principle, I do not doubt that the Anglo-Saxon stock, with its high qualities of leadership, would be maintained and even increased: otherwise, it seems to be tending toward extinction.

The land-owning problem in Germany has not yet been approached from a eugenic point of view. The colonization law passed during the revolution, with a view to the creation of many very small holdings of land, is rather dysgenic in practice.

Up to the present, Germany has no eugenic protection against undesirable immigrants, except in so far as the universal hunger and misery tend to discourage all prospective immigrants.

Alcoholism in Germany has of course not now the importance that it had before the war, because the larger part of the population is not now in a position to indulge in liquor to excess. But among the landed proprietors, who have suffered less, financially, than other classes alcohol continues to take its toll. I would consider it a great step forward, eugenically, if Germany would adopt prohibition as America has done. Unfortunately the fight against liquor is particularly difficult here, because those who control the liquor industry prevent the education of the people. They have brought almost the entire press into a dependent position, and they see to it that nothing reflecting on alcohol is allowed to appear in the

[4]Since this communication had been written, Dr. Boeters, a physician in office, has induced several sterilizations to be performed in Saxony.

newspapers. They have even sent to America various journalists instructed to report, in long or short articles, that prohibition there is a dismal failure and is leading to a general demoralization of the country. One who reads such articles almost imagines that he is back in the worst period of war-time mendacity.

A systematic campaign against veneral diseases is more urgent than ever before: they were widely enough disseminated before the war, but the war, and even more the "freedom" brought by the revolution has led to the greatest devastation. German eugenists favor universal secret registration and treatment. If such registration were introduced, the protection of those about to marry would be made much easier.

On the whole, one must say that, on the legislative side, everything yet remains to be done. The Germans are more disposed toward scientific investigation than toward practical statesmanship. It is, then, perhaps no loss that the Anglo-Saxons have an advantage in the field of eugenic legislation. Too hasty legislation in this matter may also provoke disastrous reactions. The main thing is that the eugenic education of the nation goes ahead; and it is going. Once public sentiment is won over to eugenics, the legislation will come of itself.

Brahma Cattle Resistant to Tick Fever—Not Immune

On page 26, Volume 15 of the *Journal of Heredity* in an article written by me there appears a picture bearing the title "Sacred Cattle of India Immune to Tick Fever" and the sub-title contains the words "Purebred Hindu cattle, and hybrids of this species with European cattle are immune to tick fever——." The picture is mine but the title is not mine, I did not see it until it appeared in print. Technically the title is incorrect and the words "highly resistant" should be substituted for the word "immune." In most practical applications this should not make much difference, but in some of the scientific implications and in the practical problem of whether the Brahma cattle could be carriers of the disease the distinction is a very real one and therefore this correction should be made.—Jay L. Lush, *Texas Agricultural Experiment Station.*

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A New Approach to Biology

ASCARIS: Eine Einfuehrung in die Wissenschaft vom Leben fuer Jedermann. Dr. Richard Goldschmidt, Kaiser Wilhelm-Institut f. Biologie, Berlin-Dahlem. Pp. 296, with 163 illus., price $1.00. Theod. Thomas Verlag, Leipzig, 1922.

When a child has worms, the mother's only idea is to get rid of them at once. In so doing she is losing an opportunity to get an introduction to the whole range of biology. Dr. Goldschmidt has now supplied the introduction.

Ascaris, the text of his exegesis, is a round-worm, whitish in color. For various reasons it has been a favorite subject of study with biologists, but none has carried it so far as he has in this *tour de force*, which has been received with high praises—and deservedly so—in Germany.

Like many preachers, Dr. Goldschmidt departs widely from his text; but he comes back at the moment one expects it least, and the reader will soon be fascinated in following his mental gymnastics. Indeed, the author must have derived as much pleasure from writing this book as the reader will from perusing it. Every mention of the worm is a signal for an excursion through some new realm of nature. On the very first page, for example, occurs the inevitable remark that Ascaris lives in the intestine of other animals. This brings the query, Why is it not digested? which leads to an immediate consideration of the whole subject of adaptation to environment.

Some of these transitions are, of course, a bit far-fetched, like the introduction of jokes in an after-dinner speech, or the dragging in of "lyrics" in a comic opera. A discussion of something about oysters, for instance, closes with a remark that oysters are eaten by almost everyone in America (a contrast to Germany, where they are a rare luxury). The observation follows that another common habit of Americans is to drink soda water through a long straw; this reminds Dr. Goldschmidt of various animals that have long beaks or mouth-parts comparable to the American's straw; and so the story runs on, with an unlimited wealth of illustration and interest. Before he finishes, Dr. Goldschmidt has managed to touch almost everything in biology, even through Mendelism.

While the author thinks his book is suitable for "everyone who knows how to read," this remains to be seen. Many literate people might not, at least, care for a text-book of biology, no matter how attractive. But for the boy or girl, of high school or early college age, who had a taste for natural science, the volume ought to prove a treasure-house. Indeed, I am convinced that the text-book of the future will be much on this order. At present the authors of biological text-books cling like barnacles to the idea of proceeding from the unknown to the known. Some choose the unicellular organism as a point of departure; others commence with the more abstract principles of morphology and cytology. Dr. Goldschmidt has come very near to adopting the natural and rational method of presenting biology—or at least, what seems to me to be such. His professional standing is sufficient guarantee that he has not sacrificed truth to a desire to be interesting. But to interest students in the subject is not a serious offense, and he is unquestionably interesting. Teachers of biology cannot afford to overlook this book, even though they be the last persons for whom it was intended.

P. P.

CROSS POLLINATION OF TOMATOES

Varietal Differences in Amount of Natural Cross-Pollination Important Factor in Selection

J. W. Lesley

Agricultural Experiment Station, University of California

Magnus Dwarf Champion

LONG STYLED AND SHORT STYLED TOMATO FLOWERS ENTIRE AND IN CROSS SECTION

FIGURE 20. In the variety Magnus the style projects above the stamens, and in Dwarf Champion the staminal cone is longer than the style. The long styled flowers are more subject to natural cross-pollination than the others—an important factor in selection and breeding work.

UNDER field conditions tomatoes are generally considered to be self-fertilizing, but some cross-fertilization was demonstrated and its amount measured by D. F. Jones[3]* under field conditions in Connecticut. He found that about four per cent. of cross-fertilization occurred in a dwarf variety which was planted alternately with one having a standard vine in a single isolated row with three feet between plants.

*For numbered reverences see "Literature Cited" at end of article.

In California tomatoes are grown under conditions widely different from those of the Atlantic seaboard; it could not be assumed therefore that they are cross-fertilized to the same extent. This quantity is an important one to the seed-grower and breeder of new varieties. For instance, in single plant selection work it is often convenient, especially in outlying fields, to use seed from open-pollinated plants. In case such seed is the product of self-fertilization it will, of course, lead to the immediate isolation of a pure line, and further selection will not be effective, but if cross-fertilization has occurred and the seed is from a heterozygous parent plant, segregation will occur and further selection will be possible.

The writer recently investigated the amount of natural crossing in two varieties under the conditions obtaining at the Citrus Experiment Station, Riverside, California. Two convenient indicators of natural crossing were chosen, the dwarf character, a simple recessive to standard habit of vine; and potato leaf, a simple recessive to cut leaf. These characters are recognizable with fair certainty in young seedlings from four to six weeks after seed planting.

The varieties employed were Dwarf Champion, a dwarf, cut-leaved type and Magnus, a standard vine, potato leaf type. These two varieties were planted alternately in two rows with seven feet between rows and three feet between plants in the row. On September 22, 1923, two ripe fruits were taken from each of four plants of each variety. The two lots of seed were planted in a greenhouse bed with a dibbler, that from the dwarfs being set 2×1 inches and that from the potato leaf 1×1 inches apart.

Of the potato leaf variety 1387, or 92 per cent, of the seeds germinated, but twenty-seven seedlings were so abnormal that they could not be classified, many developing no cotyledons or leaves but only a club shaped axis rather the shape of a short lucifer match. Of those which developed normally 2.45 per cent. bore cut leaves. From 1190 seeds of Dwarf Champion planted, 1025, or 86 per cent, germinated. Of these only three were standard, or 0.293 per cent. Assuming that the appearance of the dominant character, cut leaf, from a potato leaf mother and of a dominant character, standard, from a dwarf is due to cross-fertilization and not mutation, it follows that some crossing has occurred in both varieties. Cross-fertilization may be by means of pollen from another flower of the same plant or of another plant, but only cross-fertilization by pollen of a plant of a different type is directly measured here; it is therefore necessary to multiply the observed proportion of hybrids by some factor. The spacing and arrangement of the plants was similar to that used by D. F. Jones (loc. cit.) and it seems reasonable to use the factor two suggested by him. Multiplying the observed proportion by two gives 4.9 per cent cross-fertilization for Magnus and 0.59 per cent for Dwarf Champion.

The difference between these percentages is almost certainly a significant one,*

The variety Dwarf Champion is, therefore, less subject to cross-fertilization than the variety Magnus. Various factors may be responsible for this varietal difference, such as selective fertilization, cross incompatibility, differential viability of embryos and so on. A probable cause, however, lies in an observed difference in the floral structure. Tomato varieties differ in the position of the stigma relative to the anthers in the flower. In some the stigma protrudes beyond the staminal cone; such varieties may be termed long styled. In others the stigma is below the top of the staminal cone,

*The weighted mean percentage is 3.07 and its standard error .71. The difference between the observed percentages is 4.32, or more than six times the standard error (nine times the probable error).

such varieties being short styled. Intermediate types occur. Evidently the protruding stigma of the long styled flower is more exposed than that of a short styled flower, which is sunk in the tube formed by the anthers and partially protected from insect and wind-borne pollen. Two species of bumble bee were frequently seen systematically visiting tomato flowers at Riverside, and these insects would be more likely to cross-pollinate long styled flowers. A protruding stigma is also more exposed to wind-borne pollen. Under greenhouse conditions White[5] found that the short styled varieties set fruit more freely than long styled without hand pollination, which suggests a more reliable mechanism for natural self pollination in short styled flowers. This may well be true also under field conditions. Meade[4] has noted a similar difference in varieties of cotton. Both from the less exposed position of the stigma and a more reliable mechanism for self pollination, therefore a short styled variety would be less subject to cross-fertilization than a long styled one. The variety Magnus is long styled, the stigma being on the average about 1.4 millimeters above the apex og the staminal cone (Figure 20). This variety showed correspondingly more cross-fertilization. Dwarf Champion, on the other hand is short styled, the stigma being usually sunk about one millimeter below the apex of the staminal cone but occasionally level with it (Figure 20). Correspondingly less cross-fertilization was found in this variety. It appears then that both these varieties are cross pollinated to some extent. The amount differs, however, in the two varieties and it follows that comparison of the amount of cross-pollination in tomatoes under different environmental conditions may not be made without regard to variety.

Probably most if not all tomato varieties consist of a mixed population involving several gene differences. Such differences may not be of an obvious kind, but may yet be of economic importance, such as those affecting size of fruit and yield. A considerable proportion of the plants may be hybrids, especially in a variety rather subject to cross-fertilization such as Magnus. According to Henkels[2] and to Becking[1], if only three gene differences are involved after many generations with five per cent cross-fertilization the population will contain ten per cent of plants heterozygous for one or more of these genes. Such heterozygous plants if self-fertilized will show segregation and response to further selection. Moreover, if unprotected seed is used there is the further chance that it is in part an immediate product of cross-fertilization.

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The Chinese Banana in the Pacific Islands

The storm was followed by a great scarcity of food. In Samoa, as elsewhere, calamities seldom come alone. A severe storm makes great havoc among the cocoa-nuts and bread-fruit and bananas in all places exposed to its ravages. The taro plantations, on which article the Samoans depend at least as much as upon the bread-fruit, are not of a character to be much injured by the hurricanes; but, almost invariably after one of these comes a caterpillar, which eats up the leaves of the taro, and this renders the root

almost, if not quite, unfit for food; hence famine follows in the wake of the storm, and famine is apt to affect health, so the calamity becomes threefold.

There is a remarkable provision in the Samoan, and I suppose other groups of islands also, which is of great value to the people in times of scarcity. A yam is found in the bush which grows without cultivation, and which, I think, is never quite exhausted. It is much inferior to the cultivated yam, and is not to be compared with taro, and it has to be dug from a depth of four, five or more feet, and generally it has to be carried from a considerable distance; still, it can be got, and, with what bananas and cocoa-nuts may have escaped the storm, it enables the people to struggle along till times of plenty return. I have mentioned bananas, but the bananas indigenous to the islands have a poor chance when a hurricane sweeps over them. There is one kind, however, the Chinese (*Musa cavendishii*), which now grows abundantly throughout the South Seas, which is valuable at all times, and especially so when ordinary resources fail, connected with which there is a tale worth preserving. When Mr. Williams reached Samoa in the "Camden" in 1838, he brought with him a number of plants, which had been furnished by the Duke of Devonshire, with a view to their being introduced to the islands of Polynesia. Among these was a root of the Chinese banana. It appeared to Mr. Williams to have lost its vitality, and so satisfied was he of this that he threw it away. It caught the eye of Mr. Mills, who was the missionary at Apia at the time, and it struck him that it might possibly grow. At all events, there would be nothing lost by giving it a trial. A trial was made, and the result was that it did grow, and from that apparently dead root, every group, and every inhabited island of any considerable extent south of the equator, has been furnished with the Chinese banana, and its value to the natives is beyond all computation. It is low, and embeds itself more deeply in the soil than the native bananas, and so it escapes, and lives through the ravages of storms which destroy these. It grows with or without culture, but it amply repays the attention which it receives. I have seen bunches from plants that have been tended and cared for, so large as to require two men to carry them conveniently. And another of its superior qualities is that it bears in a much shorter time than the island bananas.

Our teachers have taken the plant, whose value is now so well known, wherever they have gone, and by their means, and that of other parties, the said banana is now found throughout the wide Pacific from Tahiti—I daresay I might include the Marquessas—to the islands of Torres Straits and the mainland of New Guinea. (*Forty Years' Mission Work in Polynesia and New Guinea*, by Rev. A. W. Murray, Pp. 270-271.)

MEIOSIS AND CROSSING-OVER

R. Ruggles Gates

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YOUR correspondent, Dr. P. W. Whiting,[14]* in an article which he styles "a reply" to some critical remarks of mine[7] in your journal, does not display as much knowledge of meiosis in plants as one would like to see. He has not grasped the significance of the facts in the paper on plant chromosomes which he cites, and he makes the not uncommon mistake of confusing theoretical conceptions and issues with the actual facts of observation.

Preconceived notions of what ought to be, should always be strictly subordinated to critical observation of the facts themselves. Conformity to this rule is nowhere more essential than in cytology, where a slight bias easily distorts the observations or the interpretation placed upon them. One could cite a number of such cases from the literature of the last ten years. If, however, the facts are correctly recorded, they will bear the weight of later theoretical interpretations. But nothing is more fatal to progress than to mix up fact and theory, and to assume that because the facts do not fit in with our preconceived notions they must therefore be wrong.

As a matter of fact, Dr. Whiting simply repeats in another form the inaccurate statements which I originally pointed out, to the effect that because chromosome tetrads are present in some animals they must also be present in all plants. If he will read up the literature of meiosis in plants, including Sharp's *Introduction to Cytology*, to which I originally referred, he will find that progressive plant cytologists have given up the notion that tetrads *must* be present whether they can be seen or not.

The time when it was possible to fit all meiotic phenomena into one story has long since passed. I may mention a few points in my own experience on this subject. In 1910 I had the opportunity of examining Janssen's preparations of Batrachoceps, and was convinced of the correctness of the parasynaptic account in that form. Some time ago Dr. Wenrich kindly sent me some of his preparations of Phrynotettix, to which Dr. Whiting refers, and from a study of these I am convinced that in the heterotypic prophase a lateral pairing of leptotene threads takes place to form a zygonema, as Wenrich states. The parasynaptic account is, I think, very probably true of both these forms. But I am equally convinced that the telosynaptic account is true of Oenothera. Probably the cytological significance of this distinction, however, has been much over-estimated.

It may be pointed out that in no other plant, or animal either for that matter, has there been such unanimity of opinion regarding the phenomena of meiosis as in Oenothera. Since my original paper in 1908,[3] there have been similar accounts by three other investigators, Geerts[6], Davis[2,3] and Cleland[1], all of which have repeated the telosynaptic story, agreeing with each other in all essentials, and even in most of the details, except in certain interesting points where actual differences exist. No one I am sure would accuse these writers of endeavoring to make their results agree with mine, or of a bias in favour of my account. Yet they did agree in

*For numbered references, see "Literature Cited" at end of article.

all essentials. It should also be said that I have repeated the same observations many times on other Oenotheras since 1908. I was fortunate in that paper in obtaining certain critical but transitory stages in the segmentation of the spireme (pachynema) to form a string of chromosomes—stages some of which have not been figured since. (See, for example, particularly figures 18, 22, 23 and 24 of that paper). These stages especially prove that the heavy spireme segments into a single (not double) chain of fourteen chromosomes, with the exception that in some cases one or more pairs are cut off at an earlier stage.

Those who fancy that they can still torture the facts into a parasynaptic story have left one thing out of account. Let us assume for the moment that the pachynema does represent two parallel threads fused. Then, since this spireme afterwards segments into the somatic number of chromosomes arranged (at first) end-to-end, the fourteen chromosomes in diakinesis must have arisen through the lateral fusion of threads representing two chromosomes and their subsequent transverse segmentation *in the middle* of the chromosomes as well as between them. In other words, each chromosome on the heterotypic spindle would consist of half the lengths of a pair of homologous chromosomes, and the conception of the chromosomes maintaining their individuality during meiosis would be destroyed. They would instead be reconstituted by the lateral fusion of a pair of chromosomes followed by their transverse segmentation into two new bodies.

Dr. Whiting quotes a statement in my early paper (1908) to the effect that in the stages where a pairing of leptotene threads might be expected, "parallel threads could not be observed, and it has not been determined whether they were really absent or whether the failure to observe them was due to their extreme delicacy." That statement was merely made in the first detailed paper on meiosis in Oenothera, in order to show that I was free from bias and quite prepared to find parallel threads if they occurred. I had in fact anticipated finding a parasynaptic pairing, but the facts proved otherwise, and the great number of subsequent observations by various investigators have progressively strengthened the case for telosynapsis in Oenothera.

Dr. Whiting assumes that parallel threads in the early leptotene stage would be a proof of parasynapsis. A further acquaintance with the literature of plant cytology would have shown him that this conclusion by no means follows, since a double thread may arise from a split as well as an approximation. Such a split has often been interpreted as being a premature split which reappears later to separate the halves of the homotypic chromosomes. The mere presence of double threads is therefore not sufficient. It must be shown whether they arise from a split or an approximation. But since they have not been shown to occur in Oenothera we need not be further concerned with them.

It is as well that geneticists should recognize clearly the alternatives involved, namely an essentially telosynaptic account of meiosis in Oenothera or a denial of chromosome individuality. A parasynaptic account would not only involve a reconstruction of the chromosomes in meiosis but would also, in the failure of whole somatic chromosome pairs to conjugate and separate, upset the basis for Mendelian behaviour, and we know that such behaviour occurs in a few characters in this genus. This is true for example, of the red bud character of *Oe. rubricalyx* in crosses with nearly related forms, although when crossed with more distantly related species such as *Oe. grandiflora* the character may be broken up by back-crosses and diluted out of recognition[5]. As I have shown elsewhere[4], in crosses

between *Oe. rubricalyx* and *Oe. grandiflora* all characters except the red buds are intermediate in F_1 and variously modified in F_2.

The denial of telosynapsis, in order to provide a possible basis for crossing-over in Oenothera, would involve a denial of chromosome individuality in these forms and deprive us of what is usually regarded as the basis for Mendelian inheritance.

We may now look for a moment at the situation as regards genetical crossing-over in Oenothera, since Whiting has already referred to this point. Shull[13] makes the announcement that he has found crossing-over in Oenothera, but there are at least two reasons why his statements can only at present be accepted with reserve. One is that he has not yet published the full facts on which his statements rest, another that his experiments were carried out with material from a hybrid source where he at first thought he had pure *Oe. rubricalyx*.

When his first paper on *rubricalyx* crosses came out[13], I had just published an extended account[4] of two generations of crosses and back-crosses between *Oe. rubricalyx* and *Oe. grandiflora*. From this paper Shull recognized that his supposed *rubricalyx* was in reality a hybrid with *Oe. grandiflora*. Not only the red spots on the leaves but also the more slender, rounded buds and the leaf-shape, as well as other characteristics, gave the situation away. Shull referred to this in several places in his paper. First (footnote p. 84) he said, "Several features of my plants suggested a relationship to *Oe. grandiflora*, particularly the rather lax rosettes, strong red spotting of the young rosette-leaves, and the development of buds more slender and rounder than in my *Oe. rubrinervis* cultures." Again (p. 88) he said, "The fact that half of my *rubricalyx* plants had strongly spotted leaves may perhaps mean, therefore, that my original *rubricalyx* plants were hybrids." To anyone familiar with these forms this conclusion was certain and inevitable! Some of the misstatements in that paper were briefly pointed out.[a]

Under these circumstances one cannot avoid being skeptical as to the authenticity of Shull's conclusions regarding crossing-over in Oenothera. If it occurs as a regular phenomenon in this genus it will, so far from strengthening the current conceptions of the physical basis of crossing-over, make it necessary to view the process in quite a different light. At present it is at least sounder to retain a view which is in accordance with the cytological facts and which leaves us also with the usual chromosome basis for Mendelian inheritance.

Jennings[10] has recently shown mathematically the strength of the position as regards the theory of crossing-over and interference in Drosphila. But it is impossible to argue with safety from a fly to a flowering plant in such details of chromosome behaviour, and the known cytological facts are all against such an assumption. On the contrary, we have shown[8] that an important difference in this very point of the crossing-over or twisting about each other of chromosome pairs exists between *Oenothera* and *Lactuca*. In the latter genus, as well as in certain other genera of plants, this intertwining of the chromosomes in a pair is a common occurrence, and furnishes exactly the basis desired for genetical crossing-over, while in Oenothera no cytological basis for such a phenomenon has been observed.

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The Inheritance of Defects

Einfuehrung in die Allgemeine und Spezielle Vererbungs-Pathologie des Menschen, Ein Lehrbuch fuer Studierende und Aertzte, by Dr. Hermann Werner Siemens, Privatdozent of Dermatology at the University of Munich. 2d ed., revised and enlarged; pp. 286, with 96 illus. and pedigree charts, price $2.90. Berlin, Verlag von Julius Springer, 1923.

While the special literature concerned with the inheritance of defects and abnormalities is large, the labor of collecting it has deterred most bibliographers, and there are available few works of reference on the subject—indeed, one often has to go back to C. B. Davenport's *Heredity in Relation to Eugenics,* which was published in 1911, and therefore does not include much later work. Lucien Howe's *Bibliography of Hereditary Eye Defects* (Eugenics Record Office Bulletin No. 21, 1921) represents a type of work that is much needed. S. J. Holmes did not attempt to enumerate all papers in this field in his monumental bibliography of eugenics.

Dr. Siemens has undertaken to abstract, analyze and digest the literature in the whole field of pathological heredity, and his work, being the most comprehensive now available, will be of great value to all workers in this field. Unfortunately, the interruption of international communications during the war—an interruption that has not yet been wholly relieved—prevented him from having access to a good deal of valuable work in the English language—work that he will doubtless include in future editions as it becomes available to him.

The author gives up the first third of his book to general considerations or heredity and pathology, the second third to a detailed consideration of the various types of inheritance, richly illustrated from the field of disease; while fifty pages are given over to an alphabetical list of diseases and defects, with a notation of the genetic data available in regard to each one. In this difficult task Dr. Siemens has been conservative.

A vocabulary and bibliography complete this work.

The book is addressed particularly to physicians—a fact which might be taken to indicate that German physicians are generally interested in the problem of inheritance. It is to be wished that the same assumption could be made truthfully of American physicians as a class. P. P.